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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF HEALTH

The Australian Institute *of* Tropical Medicine

Townsville
North Queensland

Collected Papers

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Clinical, Pathological and Experimental Observations on the "Mysterious Disease," a Clinically Aberrant Form of Acute Poliomyelitis.

BY

A. BREINL, M.D.,

From the Australian Institute of Tropical Medicine, Townsville.

REPRINT FROM
The Medical Journal of Australia,
16th and 23rd March, 1918.

CLINICAL, PATHOLOGICAL AND EXPERIMENTAL OBSERVATIONS ON THE "MYSTERIOUS DISEASE," A CLINICALLY ABERRANT FORM OF ACUTE POLIOMYELITIS.

By **A. Breinl, M.D.**

From the Australian Institute of Tropical Medicine, Townsville.

Within the last year there appeared in parts of Queensland and New South Wales, a number of cases of a mysterious disease, apparently not observed previously, which had an alarming mortality. Litchfield[1] recorded the first case from Broken Hill. The patient was a child, two years of age, which "had been taken ill suddenly and within three hours was in convulsions with a temperature of 103° F." From a blood culture a Gram-negative diplococcus was obtained, which unfortunately was not further studied. He pointed out at the time that these mysterious cases were still occurring in considerable numbers in the neighbourhood of Bourke, and that more recently the disease had affected adults as well as children. In a letter[2] I drew attention to the fact that cases with similar clinical symptoms occurred about the same time in Townsville, and that the post-mortem appearances of the brain and spinal cord of the first case were macroscopically and microscopically identical with those of a typical case of acute poliomyelitis, with extensive involvement of the grey substance of the brain. This letter was replied to by Cleland and Bradley,[3] who had examined sections of the medulla of a patient in the country case in which lesions indistinguishable from those of acute anterior poliomyelitis were present, and recorded in two other cases the occurrence of marked paresis of the limbs as an aftermath of the acute infection, and considered the possibility "that it may be due to some virus allied to that of acute anterior poliomyelitis, producing a disease which has hitherto not been differentiated from the latter."

A further contribution was made by Burnell,[4] describing an epidemic of an obscure disease at Broken Hill, with a high mortality; out of fifteen cases twelve ended fatally.

The patients suffered from great weakness, and after a period of from one to two days passed into a condition of semi-consciousness. He stated that the patient, on admission to the hospital, might be lying with both eyes open, apparently in very little pain, would on request put out his tongue, but was unable to grasp longer or complicated sentences. "A marked feature was the peculiar resistiveness, the patient gently but firmly resisting any manipulations one may attempt to make with his limbs." The temperature was elevated, ranging between 101° and 107° F.. The day following the mental condition had changed, a state of profound unconsciousness had set in, with head retraction and intermittent clonic convulsions followed later by increase in respiration, and frequently a typical respiratory death supervened. The duration of the disease in fatal cases was three to five days. In the non-fatal cases the patients never showed the respiratory embarrassment, and in two of them, after weeks of apyrexia, delusions were still present. The brain was examined in three cases, in two of them the meninges were normal, in the third there was slight injection of the *pia mater* and marked œdema of the brain substance. Otherwise the internal organs appeared normal. The cerebrospinal fluid of seven cases out of the ten gave culturally a short, non-motile, non-spore-forming bacillus, which proved non-pathogenic to guinea-pigs and rabbits.

Cleland, Bradley and Buckley[5] in a further communication gave a short account of the mysterious disease in New South Wales. The clinical symptoms were the same as those recorded by other observers. After one or two days of malaise the patients became stuporous, semi-comatose or irritable, the temperature rose to 39.5° C. (103° F.), or even 41.7° C. (105.1° F.), and tetanic convulsions preceded death, which occurred within a week of the onset. They stated that "in the non-fatal cases there was a gradual and irregular fall of temperature and a slow improvement. In one or two cases there was paresis of the muscles of the extremities." The lumbar puncture gave a clear fluid in the majority of cases. The total mortality was 61%. The post-mortem revealed in a few cases enlarged Peyer's patches of the intestinal mucosa and enlarged mesenteric lymph glands. "Some fine punctate hæmorrhages were present in one brain, definite œdema in another, and congestion in three brains," but no obvious meningitis. The sections of the medulla and the upper spinal cord of one case (that of a child which had died at Narrabri) showed various areas of round cell infiltration, with destruction of nerve cells and congestion, a condition "very suggestive of the lesions found in acute anterior poliomyelitis." Negative results were obtained on injecting an emulsion of parts of the brain and spinal cord into the peritoneal cavity of a monkey. The authors pointed out that the cerebro-spinal fluid from other cases failed to produce any ill effect on monkeys, guinea-pigs and rabbits, and suggested the term "cerebral fever" for the condition.

Anderson[6] recorded careful clinical observations of fourteen cases of the mysterious disease from the Goondiwindi district in Southern Queensland, of which six ended fatally. Twelve of his patients were under ten years of age. The onset of the disease was sudden, with headache, high fever and convulsions, followed by deep coma. Two of his patients developed unilateral paresis, from which they completely recovered.

Mathewson[7] had under his care at the Brisbane Children's Hospital seventeen patients suffering from a similar disease, out of which number eleven died. The onset of the disease was mostly sudden. A child, previously healthy, developed a high temperature and was seized with convulsions, which continued with intervals of semi-consciousness for days, the child afterwards lapsing into a state of stupor and finally deep unconsciousness. In other cases the onset was insidious, the child complaining of headache and vomiting, and passing afterwards into the stages of stupor and unconsciousness. Three of the six patients who recovered, had not regained normal intelligence.

The bacteriological examination of the cerebrospinal fluid proved negative. The pathological report on the histological examination of the brain and a small portion of the upper cervical region of the cord of one case by Latham, described the main pathological changes as a "widespread congestion of the blood vessels of the brain and spinal cord and an infiltration in their adventitial sheath, with large and small mononuclear cells, including plasma cells." The ganglion cells appeared to have been but little affected, even those situated in the midst of hæmorrhages or islet of cells.

During the months of March, April and May, 1917, a number of patients were admitted to the Townsville Hospital suffering from a disease, the symptoms of which did not entirely agree with any hitherto described ailment, but corresponded in all details to the cases of the "mysterious disease" or "cerebral fever." The high mortality—out of seven cases five ended fatally—and the obscure nature of the disease warranted a careful clinical, pathological and experimental investigation.

Circumstances enabled me to obtain autopsies on five cases, and the brain and spinal cord of these cases was subjected to further histological examination. Within the last month two further cases of the same disease were observed in Townsville. Both ended fatally, and the brain and spinal cord were utilized for further investigation. The interest which the cases in question have aroused, and their obscure nature, warrant a publication of the results of the clinical and pathological observations in detail.

Case 1.—A boy, seven years of age, was admitted on March 6, 1917 (*see* Chart I.). The history showed that the boy had been "off colour" for a few days prior to admission. On March 4 he had a fit, accompanied by high fever, after which the patient became unconscious for a short time. The following day his general condition was slightly improved, and he had, to a certain extent, regained consciousness. The improvement, however, was only temporary, and his condition becoming worse, he was taken to the hospital.

On admission, the boy was semi-conscious, and looked very ill. The physical examination did not reveal any striking changes, beyond a slight stiffness of the neck and an expression of pain in his face whenever his arms or legs were moved. His tongue was furred. The Widal reaction of his blood serum was negative; the urine contained only traces of albumin, but no sediment.

In the course of the following two days his general condition remained the same, and on the third day the patient appeared slightly improved; he slept peacefully during the day, but was restless at night, throwing himself about in the bed, calling out, and repeatedly attempting to get out of bed. On the fifth day after admission his temperature had become nearly normal, he began to take interest in his surroundings and answered simple questions sensibly, but was unable to grasp the meaning of more complicated sentences, and took nourishment better. The improvement was, however, only temporary. In the course of the morning of the sixth day his temperature rose, and convulsions of short duration set in, followed by unconsciousness; in the free intervals the legs and arms showed muscular twitchings. The neck was rigid; neither Babinski's nor Kernig's sign was present, and the patellar reflexes were not exaggerated; the respiration was deep and stertorous, the rate increased to about thirty-two. On account of the inability of the patient to swallow, rectal nutrient enemata were administered.

The lumbar puncture, performed on 12th, yielded a clear cerebro-spinal fluid, apparently not under increased pressure. The sediment consisted of a small number of lymphocytes only, and proved sterile on bacteriological culture.

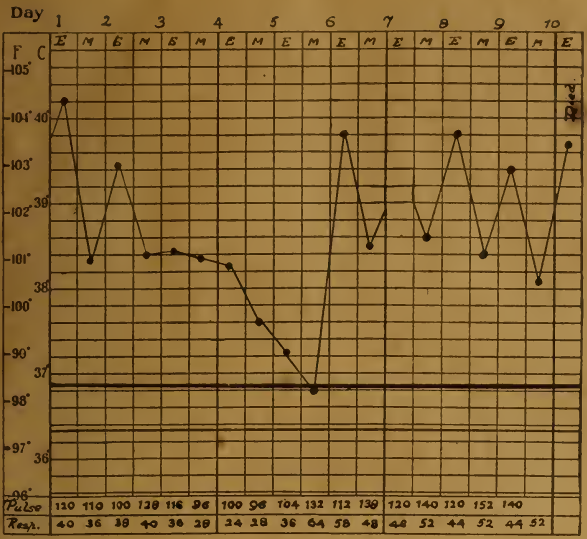

Chart I.

The patient's condition thereafter became steadily worse; he was totally unconscious, and passed his urine and small, yellow, normal motions in the bed. At frequent intervals he stiffened himself out; the fingers were partly flexed, and legs and arms shaking at first slowly, the rhythm gradually increasing, resembling somewhat a tetanic spasm. The convulsions increased steadily but slowly in frequency and severity, the respiration became more frequent and shallow, and the patient died on the tenth day after admission.

The autopsy was performed twelve hours after death. The chest organs appeared normal to the naked eye; the heart muscle was perhaps slightly flabby. There was no free fluid in the abdominal cavity, the liver showed cloudy swelling, the spleen was not enlarged, the kidneys appeared normal. The intestine was normal, the mesenteric lymph glands on the whole were enlarged and appeared on cross-section œdematous.

The *dura mater* of the brain firmly adhered to the skull. The veins of the pia-arachnoid were considerably congested. The brain substance was œdematous on cross-section, soft and congested, and the basal ganglia were the seat of numerous small hæmorrhages. On cross-section the grey substance of the spinal cord was slightly prominent, and of a pinkish grey colour, showing small hæmorrhages here and there, perhaps more numerous in the anterior horns.

Brain and spinal cord were fixed *in toto* in 4%

formalin, and pieces of the different regions prepared for microscopical examination. The paraffin sections were stained with hæmatoxylin-eosin and Van Gieson's stain, by Weigert's myelin method, and with saffranin-methylene-blue-orange tannin, after having been treated with an alcoholic solution of iodine as mordant, a method utilized previously by me for staining protozoa in wet films.[8] The latter stain was useful for the demonstration of the granules of Nissl in the ganglion cells.

Microscopically the most remarkable feature of the sections of the brain and spinal cord was the intense and general congestion of the blood vessels of the *pia mater,* and of the central nervous substance, especially of the grey matter. The perivascular lymph spaces were dilated, being here and there infiltrated with a few cells, mainly lymphocytes and a few plasma cells. Throughout the grey matter of the brain, in the cortex as well as in the large basal ganglia, were small foci of infiltration, consisting of lymphocytes and leucocytes, often but not invariably situated in the neighbourhood of ganglion cells. Similar small isolated groups of cells were noted in the white matter, but occurred less frequently, the brain tissue appearing rarefied around these foci. Many of the nerve cells were in various stages of degeneration; their outlines were irregular, their cytoplasm stained diffusely, the nucleus possessed densely staining chromatin and an indistinct nucleolus. Here and there nerve cells were surrounded by round cells, which sometimes had invaded the cells, and caused their disappearance, a process known as neuronophagia. Sometimes the neuroglia appeared slightly proliferated in the neighbourhood of these islets of cells. A number of the blood vessels showed striking changes; their walls were filled with a number of small, roundish granules of various sizes, staining dark blue with hæmatoxylin, resembling the hyaline granular degeneration of the vessel wall as found in other organs.

It was noteworthy that the lesions were irregularly distributed throughout the brain substance; hardly any foci were observed in one section, whereas numerous ones occurred in other sections of adjoining parts. Sections of the cerebellum did not reveal any lesions. The *medulla oblongata* and the spinal cord presented changes analogous to those of the brain. The blood vessels of the *pia mater* showed only a small degree of perivascular infiltration, which continued along the vessels into the spinal cord substance. The central canal appeared dilated, and the surrounding neuroglia was distinctly hypertrophic. A focal infiltration similar to that of the brain, was found irregularly distributed throughout the spinal cord, perhaps more marked in the lumbar and cervical enlargement. The whole of the grey matter showed a diffuse cellular infiltration, especially marked in the regions of the anterior horns and of the central commissure. There were numerous small islets of leucocytes and lymphocytes surrounding the nerve cells, especially the anterior polar cells; many of the cells were in various stages of degeneration, staining densely and irregularly, and not possessing Nissl's granules. In many instances only remains of the cytoplasm of the nerve cells were visible in amongst the neurophages; in other sections a clump of infiltrating cells indicated the position from which the nerve cell had disappeared. One can thus easily trace all stages of neuronophagia from the earliest stages, where the leucocytes and lymphocytes—here called neurophages—begin to surround the nerve cells, to the latest stage, where the nerve cell had completely disappeared.

The histological examination of several of the spinal ganglia showed somewhat similar lesions. A well marked, diffuse infiltration was noticed here and there, and a distinct degeneration of a few of the nerve cells.

Case 2.—A boy, nineteen years of age, a painter by trade, was admitted on April 1, 1917. The history revealed that he had not been feeling well for nearly a week, and had had a severe fit on the day prior to entering the hospital, succeeded by unconsciousness. The patient was totally unconscious on admission; his arms and legs were trembling; his head was turned to one side and his neck stiff. His facial expression denoted great pain on the attempt to turn his head. His eyes were usually fixed, showing now and again slight nystagmus; the breathing was shallow, and slightly increased in frequency. Whenever touched, the patient became quite stiff, his hands were slightly bent in the wrist joint, the thumb straight and the fingers slightly flexed. His temperature was elevated (*see* Chart II.). The patient never regained consciousness; he sank into a deeper and deeper stupor, emaciating visibly from day to day, and finally died on the eighth day. Kernig's and Babinski's sign were absent. Lumbar puncture was performed on the second and sixth day; the spinal fluid was clear, apparently not under increased pressure, dripping out slowly drop by drop from the needle. The sediment showed a marked increase in formed elements; the sediment consisted of lymphocytes, leucocytes and a few red blood corpuscles. No micro-organisms could be detected on microscopic examination, and the cultivation on the usual culture media, and, besides, on trypsin agar and on human blood serum, gave entirely negative results.

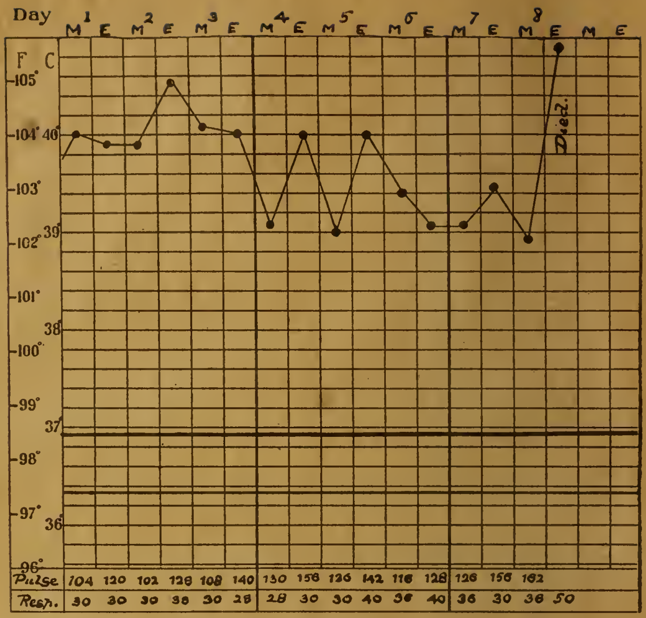

Chart II.

The autopsy was performed six hours after death. The pericardium contained about 5 c.cm. of clear, straw-coloured fluid. The heart was flabby, and its muscle friable. In the left pleural cavity, between the base of the lung and diaphragm, a small amount of thick, whitish fluid was found. Otherwise, the lungs and pleura were normal. The liver showed cloudy swelling, the gall-bladder was filled with dark, greenish bile. The spleen was not enlarged; the kidneys and intestine showed no changes.

The *dura mater* was firmly adherent to the skull. The pia and arachnoid were hyperæmic, the pial veins distended and filled with clotted blood; the convex surface of the brain was covered with a very thin layer of greyish exudate. The congestion was more pronounced over the occipital part of the brain, where the veins could be easily traced to their finest capillary branches. The meninges of the spinal cord showed similar changes. On cross-section the brain substance was soft and œdematous, and its blood vessels distended. Throughout the grey matter there were numerous hæmorrhages. Larger hæmorrhages could be detected in the medulla, especially marked below the ependym of the ventricle. The ventricle system of the brain and the central canal of the spinal cord were distended and filled with clear fluid. The spinal cord on the whole did not appear much altered to the naked eye; its substance was œdematous and hyperæmic, and there were a few hæmorrhages in the grey matter of the commissure of the lumbar swelling.

Sections were prepared of the various parts of the brain and spinal cord and examined microscopically.

The microscopical examination of the meninges of the brain showed a very marked cellular infiltration, consisting of leucocytes and lymphocytes, a pronounced distension of the blood vessels and small hæmorrhages here and there. This cellular infiltration continued along the vessels into the cortex of the brain. Sections through the large basal ganglia of the brain showed a slight but diffuse infiltration of the grey substance with round cells and a dilatation of the blood vessels. The perivascular lymph spaces were dilated and filled with coagulated lymph containing a few red blood corpuscles. There were numerous small hæmorrhages destroying the brain tissue, the blood corpuscles being in various stages of disintegration. The wall of the blood vessels showed here and there striking changes, whereby the intima and media were not well defined and the vessel wall was filled with irregular small granules of varying sizes, staining dark blue with hæmatoxylin. The majority of the ganglion cells appeared normal.

The meninges of the spinal cord showed a change similar to that of the brain, a marked cellular infiltration, consisting mostly of leucocytes, which continued along the vessels into the surface layer of the spinal cord; the vessels were distended, and small hæmorrhages were not rare. The grey substance showed a slight but well marked cell infiltration, which was irregularly distributed, more pronounced in sections through the lumbar swelling, affecting mostly the tissue surrounding the central canal.

Although sixteen pieces of the spinal cord at different levels were microscopically examined, only one section, and that through the upper part of the cervical enlargement, showed neuronophagia. One of the ganglion cells of the anterior horn was surrounded by a number of mononuclear cells, forming thus a typical focus. The nerve cells on the whole appeared normal. Sections through the spinal ganglia showed normal conditions.

In the liver tissue there was microscopically a small amount of hæmorrhagic infiltration between the acini. The kidney, spleen and lymph glands did not show any noteworthy changes.

Case 3.—A boy, one year and eight months old, was admitted to the hospital on April 26, 1917. His mother stated that the child had been in perfect health until mid-day, when he suddenly had a fit and became unconscious. Six hours afterwards he was taken to the hospital in an unconscious condition, with a subnormal temperature and a pulse-rate of 140. The muscles of his legs, arms and face were twitching continuously; his head was turned to the side. The neck was not stiff; both pupils were slightly dilated and equal, and he showed neither squint nor nystagmus. The following day his temperature rose to 40.5° C. (*compare* Chart III.) and his pulse-rate was 170; cold packing for one hour reduced the temperature to 38.9° C.. His bowels acted at first frequently; the stools were loose, greenish-yellow and slimy. In the course of the next few days there was hardly any change in his general condition. The patient was unconscious, twitching at intervals. On the eighth day the respiration-rate, which had been nearly normal up to then, increased in frequency; the breathing became more and more distressed, and the child died on the tenth day after admission of respiratory failure.

Lumbar puncture was performed on two occasions. The cerebro-spinal fluid was clear, and apparently not under increased pressure. The sediment contained a small number of leucocytes and lymphocytes and neither microscopical nor cultural examination revealed the presence of micro-organisms.

A post-mortem was performed two hours after death. The chest organs were normal. The liver was slightly enlarged, and in an advanced stage of fatty infiltration. All the other abdominal organs were macroscopically of normal appearance.

The *dura mater* of the brain was firmly adherent to the skull. The meninges were hyperæmic, the veins greatly distended and filled with dark fluid blood. The brain substance on cross-section was œdematous, soft and hyperæmic, but hæmorrhages could be discovered neither in the grey nor in the white matter. The ventricular system was slightly distended. The meninges of the spinal cord were of similar appearance to those of the brain. The spinal cord substance was œdematous and congested.

The microscopical examination of sections through the cortex of the brain showed no cellular infiltration of the meninges. The brain substance revealed slight cellular infiltration, which was most marked in sections of the large basal ganglia. The vessels were congested, the perivascular spaces distended. In sections of the *thalamus opticus* a few of the ganglion cells were surrounded by a number of mononuclear

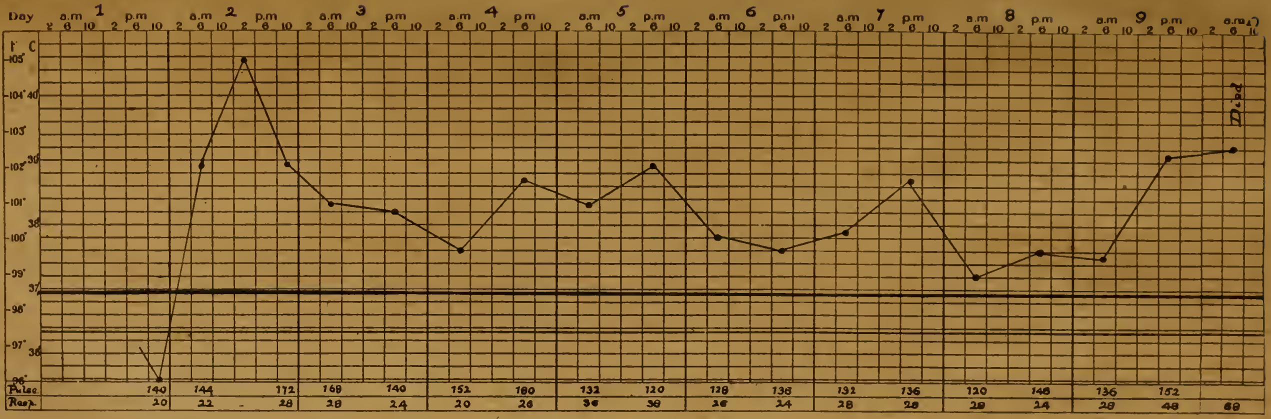
Day
1 2 3 4 5 6 7 8 9
a.m p.m
2 6 10 2 6 10
F C
105°
104° 40
103°
102° 39
101°
38
100°
99°
37
98°
97° 36
96°
Pulse
140 144 172 168 140 152 180 132 120 128 138 132 136 120 148 136 152
Resp.
20 22 - 28 28 24 20 26 36 38 26 24 28 28 28 24 28 48 68
Died

Chart III.

cells. The cerebellum appeared microscopically normal.

Sections through the pons, medulla and spinal cord showed a few foci of cellular infiltration, most marked in the neighbourhood of the dilated central canal and in the grey substance of the anterior horns. A few small hæmorrhages were seen in the grey matter of the spinal cord, especially in that of the lumbar swelling.

The microscopical examination of the liver revealed a diffuse, fatty infiltration of the liver cells, which often completely obscured its structure, and numerous small hæmorrhages were observed.

Sections of the kidney, spleen, intestine, heart muscle and spinal ganglia did not show any pathological lesions.

Case 4.—A girl, thirteen years of age, was admitted to the hospital on May 21, 1917, in the afternoon. Her employer stated that the girl had been "feeling slightly off colour" on the previous day, but still had a good appetite. During the morning of the day of admission she felt decidedly ill, and complained of headache; about mid-day she suddenly had a fit, with workings of the leg, arm and face muscles, and she became unconscious. She arrived at the hospital about 5 p.m. in an unconscious state. Her temperature was 40.5° C., her pulse-rate 132; the pulse was regular and of good quality. The respirations were deep. The patellar reflexes were exaggerated, but ankle clonus was absent. Babinski's sign was present in both feet, but Kernig's sign was absent.

Shortly after admission the patient passed a loose, dark brownish, offensive stool. The urine did not contain albumin or sugar.

A lumbar puncture was performed the following morning. The spinal fluid was clear, not under increased pressure, and the sediment contained a small number of leucocytes and lymphocytes. Cultures of the sediment on ordinary media, on trypsin agar and human blood serum remained sterile. The patient did not regain consciousness; the temperature rose to 41° C., and she died the following day at noon.

The autopsy was performed one hour after death. The thoracic organs were normal, with the exception of two small foci of infiltration at the back of the lower right lobe of the lung. The liver was slightly enlarged, showing on cross-section traces of fatty infiltration.

The *dura mater* adhered firmly to the skull. The meninges of the brain and spinal cord were hyperæmic. The brain substance appeared on cross-section soft and œdematous and congested. In the grey substance, especially in that of the *thalamus opticus* and *nucleus caudatus,* numerous small hæmorrhages were seen. The grey matter of the spinal cord appeared prominent on cross-section, of pinkish grey colour, with numerous small, punctiform hæmorrhages.

The brain and spinal cord were fixed in formalin, and sections prepared for microscopical examination.

The meninges of the brain showed microscopically a slight but diffuse infiltration with round cells, which was more marked around the blood vessels, and continued along the vessels into the surface layer of the brain. The cortex was diffusely infiltrated with leucocytes and small round cells, which formed here and there small foci, the neighbouring brain substance appearing rarefied. Small, irregular hæmorrhages were scattered throughout the cortex and white substance. The large basal ganglia showed lesions of a similar nature, but more pronounced. There was a marked small cell infiltration in the adventitial sheath of the larger- and medium-sized blood vessels; the cells were composed of lymphocytes, polymorphonuclear leucocytes and plasma cells, interspersed with larger cells possessing a large vacuolated nucleus, poor in chromatin. Below the ependym of the ventricles, as well as generally distributed throughout the grey matter, one could notice roundish or irregular foci, where the brain substance appeared rarefied, and was represented by an open meshwork of glia, with small collections of leucocytes and lymphocytes in the meshes. Smaller and larger, irregular hæmorrhages were commonly observed, and in several sections a few of the larger vessels were surrounded by a mantle of free red blood corpuscles.

A number of the ganglion cells were surrounded by cells—neurophages—and many of the nerve cells appeared in various stages of degeneration.

Sections through the pons and medulla showed analogous changes. A well marked small cell infiltration was observed around the medium-sized and larger blood vessels, and the same roundish areas of softened tissue, invaded by leucocytes and lymphocytes, were of frequent occurrence in the grey matter. The cerebellum seemed to have escaped entirely, and, excepting for congestion, the sections showed normal conditions.

In sections through the spinal cord similar lesions to those of the brain were seen, irregularly distributed, but to a greater or lesser extent present in every section. The inner layer of the pia-arachnoid was infiltrated, which infiltration followed along the vessels into the surface layers of the spinal cord. The most striking feature was numerous irregular hæmorrhages in the grey substance, mostly situated in the central commissure and in the posterior horns. Similar hæmorrhages were also present in the adjoining white matter, and a number of the ganglion cells of the anterior horn were surrounded by red blood corpuscles.

A diffuse round cell infiltration was well marked throughout the grey matter, the infiltrating cells often forming small foci. Many of the ganglion cells showed profound changes, their nuclei often staining diffusely, and their nucleoli had disappeared; neuronophagia was only occasionally seen.

A number of spinal ganglia were examined microscopically; some of the nerve cells stained diffusely, their nuclei having disappeared, otherwise no marked changes were observed.

Sections of the portions of the lung which appeared infiltrated, showed the typical picture of capillary pneumonia.

Sections of the heart, spleen, kidney, mesenteric and inguinal lymph glands appeared normal. Sections through the liver showed cloudy swelling, fatty infiltration and small hæmorrhages.

Case 5.—A boy, two years of age, was admitted to the hospital on June 4, 1917. The anamnesis taught that the patient had been in perfect health until the evening prior to his admission, when he had a sudden retching turn, followed by convulsions, which lasted off and on during the whole of the night. When admitted to the hospital he was semiconscious; his temperature was slightly raised (*see* Chart IV.). The physical examination did not reveal any striking organic changes. During the following four days he was conscious, and showed only slight twitchings in arm and face now and again. On the fifth day, however, convulsions set in again, the respiration became stertorous and laboured, and he could only swallow with the greatest difficulty. His body temperature rose, and registered 42.2° C. during the night, which, however, was

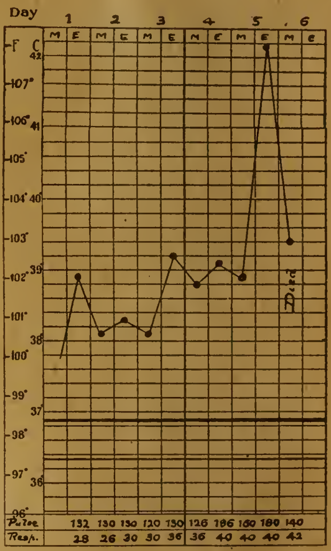

Chart IV.

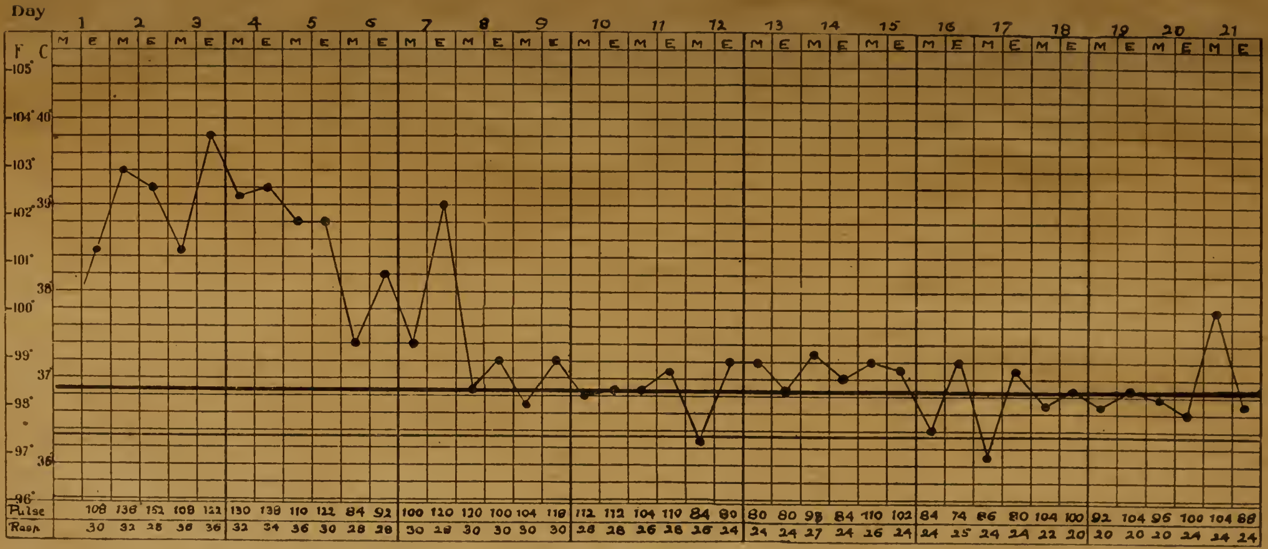
Day
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
M E
F C
105°
104° 40
103°
102° 39
101°
38
100°
99°
37
98°
97° 36
96°
Pulse 108 136 152 108 122 130 138 110 122 84 92 100 120 120 100 104 118 112 112 104 110 84 80 80 80 98 84 110 102 84 74 86 80 104 100 92 104 96 100 104 88
Resp 30 32 28 36 36 32 34 36 30 28 28 30 28 30 30 30 30 28 28 26 28 26 24 24 24 27 24 26 24 24 25 24 24 22 20 20 20 20 24 24 24

Chart V.

reduced by wet packing to 39.4° C.. The patient, however, never rallied, and died the following day in deep coma.

An autopsy was performed six hours after death. The thoracic and abdominal organs did not show any marked pathological changes.

The *dura mater* of the brain was firmly adherent to the skull. The meninges were very hyperæmic, the brain substance was soft and œdematous; the congestion was more pronounced in the grey than in the white substance. The central canal of the spinal cord was slightly distended, and the tissue was intensely hyperæmic on cross-section.

The brain and spinal cord were preserved in formalin, and pieces were imbedded and prepared for microscopical examination.

The meninges of the brain appeared normal on microscopical section. In the brain substance the perivascular lymph spaces were enlarged, containing here and there a small number of red blood corpuscles. In sections through the large basal ganglia the grey matter appeared richer in cells than normal, showing here and there small foci where the brain substance was rarified. A few fresh hæmorrhages of varying extent were seen in the sections through the large basal ganglia. The sections through the pons and cerebellum showed only hyperæmia.

In sections through the spinal cord the central canal of the spinal cord was dilated, and a slight but diffuse infiltration was noticed throughout the grey matter. Here and there were small hæmorrhages in the grey substance, perhaps more numerous in the lumbar swelling. The ganglion cells on the whole were unchanged.

Sections through liver, lung, heart muscle and lymph glands showed microscopically normal conditions; sections through the kidneys showed a slight glomerulo-nephritis.

Case 6.—A boy, six years of age, was admitted to the hospital on the evening of March 27, 1917. According to a statement of his mother, the boy had been in normal health until mid-day, when he suddenly took a severe fit, and became unconscious immediately afterwards.

On admission, the patient, a well-developed boy, was absolutely unconscious. His temperature was raised (*see* Chart V.), the muscles of his neck were rigid, his arms and legs were continually trembling; now and again the tremors became more pronounced, resembling a convulsion, and the boy cried out loudly. Babinski's sign was positive, Kernig's sign was absent, and the knee jerks were exaggerated. A lumbar puncture was performed; the spinal fluid was clear and not under increased pressure; the sediment contained lymphocytes.

Bacteriological cultures of the spinal fluid and blood proved negative. A blood count revealed a slight leucocytosis (12,000 leucocytes per c.mm.); the differential count a relative increase in the polymorpho-nuclear leucocytes.

The condition of the patient did not alter in any way during the following four days. The patient remained absolutely unconscious; the respiration-rate on the whole was not markedly increased. He had slight convulsions now and again, in spite of large doses of chloral hydrate, which were administered *per rectum*. Rectal feedings had to be resorted to, as the patient was unable to swallow. On the fifth day the left side of the face and his right arm and leg were paralysed.

No further changes were noted in the course of the succeeding three days; the body temperature was still elevated, and the patient was very restless. During the night, from the seventh to the eighth day, the patient appeared more peaceful than previously, and on the following morning the temperature of the patient, who had been perfectly unconscious the previous evening, was normal, and he asked for food.

The first voluntary movements of the arm and leg were noticed on the eighth day, after the fall of temperature, and the paralysis improved subsequently at an amazing rate, so that after three weeks the patient was able to walk unaided, and could grip any object with his previously paralysed hand.

Case 7.—A boy, thirteen years of age, was admitted to the hospital on May 4, 1917. He had been well until the morning of April 13. After getting up as usual, he was found by his parents lying on the ground, in an unconscious condition, his legs and arms moving violently. The "fit" only lasted for a few minutes, and he regained consciousness afterwards. He felt well enough to have his mid-day meal with the family, but felt "off colour" in the afternoon, and vomited. The same night he was restless, stayed in bed during the following two days, feeling "very hot." On the third day he had another turn, took several "fits," and lapsed into an unconscious state; he improved slightly in the afternoon, but appeared very drowsy, talking incoherently, and not recognizing his family. When he entered the hospital he had, according to his parents, improved considerably. He was still drowsy, but answered simple questions sensibly, although he could not grasp the meaning of more complicated sentences. His temperature was 40° C.. The physical examination did not show any abnormalities; a spinal puncture revealed normal conditions.

During the succeeding days his temperature fell gradually, and he appeared absolutely normal on the third day, and has been so ever since. He never showed any signs of paralysis.

Case 8.—A girl, two years of age, was admitted to the General Hospital on December 31, 1917, in the early morning. According to her mother, the child had been perfectly normal the previous evening. About 3 a.m. she had a convulsion, and became unconscious. On admission, her temperature was 40.2° C., her pulse-rate 160 and respiration-rate 40, and she was unconscious. During the morning she had convulsions off and on, lasting a few seconds only; she was restless, and threw her legs and arms about. During the afternoon the convulsions became more frequent and severe, and she showed true opisthotonos. Nystagmus was well marked. The bowels acted frequently; the motions were slimy, of greenish colour and offensive.

In spite of the administration of large doses of chloral hydrate the convulsions became more severe; the whole body became stiff and the back was arched; the temperature rose slowly but steadily, and prolonged cold packing reduced the temperature for a short time only. The pulse became more rapid and weak, and the following night at 3 a.m. the thermometer recorded 42.6° C.. The respiration became suddenly shallow and rapid (60), and death of respiratory failure took place at 3.30 a.m.

Only a partial autopsy could be performed six hours after death. Brain and spinal cord showed a high degree of congestion of the meninges. On cross-section the brain substance appeared œdematous and congested, and there were small hæmorrhages here and there, especially in the grey matter. The substance of the spinal cord showed changes similar to those of the brain; the grey matter on cross-section appeared prominent and of greyish pink colour.

The microscopical examination of the sections of brain and spinal cord revealed on the whole changes similar to those observed in Case 4. The *pia mater* of the brain and spinal cord showed a diffuse infiltration with leucocytes and mononuclear round cells; the vessels were dilated and engorged with red blood corpuscles. The blood vessels of the brain and spinal cord were injected. The grey substance of the brain showed a diffuse cellular infiltration; the cells were here and there collected into small foci, and the surrounding tissue was not infrequently rarefied. The blood vessels were often surrounded by a single or double layer of round cells, which possessed a small, darkly staining nucleus; in addition, there were in amongst them a few larger cells, with a vacuolated, irregular nucleus, poor in chromatin.

Small irregular hæmorrhages could be seen here and there in the brain tissue, and frequently the perivascular spaces contained a varying number of red blood corpuscles.

The pons and *medulla oblongata* showed a similar diffuse and focal infiltration, and softening of the grey matter, and, in addition, a few scattered hæmorrhages.

Section through the cerebellum appeared normal, with the exception of diffuse infiltration of the *corpus dentatum.*

Lesions of varying severity were observed throughout the whole length of the spinal cord, perhaps most marked in the lumbar region.

The grey matter, especially of the anterior horns and of the commissure, was diffusely infiltrated, and there were numerous cell foci, consisting of leucocytes and round cells, surrounding either ganglion cells or the remains of degenerating cells. Thus all stages of neuronophagia could be traced, from the earliest beginning, where a small number of wandering cells collected around the ganglion cell, which appeared slightly swollen, without Nissl's granules, to the end stage, where one could only see a badly staining remainder of the cytoplasm of the cell surrounded by a mass of phagocytes. The perivascular infiltration was hardly noticeable in the spinal cord, although the perivascular spaces were distinctly enlarged. There were a few hæmorrhages scattered throughout the grey matter.

Sections of several of the spinal ganglia showed infiltration with round cells between the ganglion cells, some of which appeared degenerated.

Case 9.—A boy, one year and ten months old, was admitted to the hospital on January 26, 1918. The mother stated that the child had been in good health until four days ago, when he complained in the evening of headache, became very restless, felt feverish and vomited. On the morning before admission the child "went into a stupor."

When admitted, the patient was unconscious, and slept most of the time; the temperature was elevated (40° C.). The eyes were drawn to one side, the pupils were contracted, the head was retracted and the muscles of the neck were stiff and rigid. Now and again tremors passed over the whole of his right side, and whenever disturbed the child threw his right arm about and stiffened his whole body. Kernig's and Babinski's signs were absent, the patellar reflexes were slightly exaggerated.

The bowels acted soon after admission; the stool was yellowish green, contained mucus, and was very offensive.

The condition of the patient remained the same for two days, but became worse during the second night. The fits became more frequent and pronounced, resembling convulsions of short duration. The right leg was drawn up, the right arm thrown about, whilst the left arm remained stiff and the hand clenched. The eyes were staring and drawn to one side. The temperature rose to 40.4° C., but could be reduced by cold packing to 39.4° C.. The pulse-rate was about 140, and the respiration-rate varied between 40 and 50. Large doses of chloral hydrate did not seem to influence the condition in any way.

The following day (January 28), the condition became still worse. The fits were more frequent and of longer duration, and between the fits the tremors of the right leg and arm never ceased. The patient, who had been able to take drinks, was now unable to swallow, and could not retain nutrient enemas.

The body temperature remained high, ranging between 39.4° and 40.2° C.. The pulse-rate finally rose to 168, and the patient died on January 29 at noon.

Spinal puncture was performed on January 28 with negative result.

A partial autopsy was performed one hour after death, at which the brain and spinal cord were removed. These organs resembled closely those of the previous case. There was a high degree of congestion of the meninges. The brain substance was soft and œdematous, and there were numerous small hæmorrhages in the substance of the large basal ganglia, especially numerous and extensive below the ependym of the lateral ventricles. The spinal cord was congested, and the grey matter prominent on cross-section and of a pinkish colour. The brain and spinal cord were fixed in formalin, and sections prepared.

The microscopical examination of the brain and spinal cord showed pathological lesions similar to those described in the previous case. The *pia mater* of the brain was slightly infiltrated, especially in the layer adjacent to the cortex. The blood vessels in the sections of the different parts of the brain were congested. There was a slight but diffuse cellular infiltration, especially marked in the grey substance, where the infiltrating cells, polymorpho-nuclear leucocytes and round cells, were often clustered together, forming dense small foci. The brain matter around these foci appeared now and again softened. The blood vessels here and there were surrounded by a few layers of round cells. Small hæmorrhages occurred frequently in the grey matter, and a series of larger hæmorrhages was seen below the ependym of the lateral ventricles.

The pons and *medulla oblongata* were the site of similar lesions, but the perivascular infiltration was on the whole more pronounced.

Sections through the cerebellum appeared normal.

The lesions throughout the spinal cord were most pronounced, increasing in severity towards the lumbar region. The grey matter was diffusely infiltrated with polymorpho-nuclear leucocytes and round cells, which formed here and there larger and smaller dense foci. There was an extensive destruction of the tissue of the anterior horns, most extensive in the regions of the cervical and lumbar swelling, the site of numerous smaller and larger hæmorrhages. The blood vessels throughout the cord showed marked perivascular infiltration. A number of ganglion cells were in different stages of degeneration; many of them, especially in the anterior horns, were surrounded by neurophages, and the various phases of neuronophagia were of frequent occurrence.

Small hæmorrhages were found throughout the grey substance.

Four spinal ganglia were examined microscopically, but did not show any definite pathological lesions.

Experimental.

The microscopical examination of the brain and spinal cord of the first patient suffering from the disease in question revealed pathological changes in the central nervous system, typical of acute poliomyelitis. It was therefore deemed advisable to inoculate material from further cases, should any occur, into monkeys, in order to confirm the diagnosis. The experiments of Landsteiner and Popper,[9] Flexner and Lewis[10] and others had proved conclusively that monkeys were the only experimental animals susceptible to the virus of poliomyelitis, and that intracerebral inoculation produced in these animals a definite and mostly fatal disease, which resembled the human disease in several of its most important clinical aspects, producing at the same time typical lesions in the tissue of brain and spinal cord.

The cerebro-spinal fluid of Case 4, withdrawn on the day previous to the death of the patient, was utilized, and was injected intra-cerebrally on May 25, 1917, into two animals after trephining the skull by means of an Archimedian drill. One large animal (*Macacus rhesus*) received 2 c.cm., and was found dead the following day; the second monkey (*Cercopithecus ? sp.*) received 0.5 c.cm. This animal recovered quickly from the after-effects of the anæsthetic, and appeared normal until the tenth day succeeding the operation, when he began to show paralysis of his legs. At first the animal could still sit up, but was unable to make use of his legs; his facial expression became anxious, and he appeared very ill. The paralysis progressed during the following two days; the animal remained lying on its side, unable to move, and appeared quite listless. The general condition became worse, and the animal was chloroformed on the evening of the sixteenth day after inoculation (June 6).

During the course of the disease the animal had never shown any rise in temperature.

At the autopsy the animal appeared slightly emaciated. The meninges were hyperæmic, the brain and spinal cord substance, especially the grey matter, appeared œdematous and congested. The site of inoculation did not show any changes. The organs of the body were normal to the naked eye.

Material was preserved in formalin for further microscopical examination, and pieces were imbedded in paraffin and stained by the same methods as the human material.

In microscopical sections of the brain, the meninges showed a slight but diffuse infiltration with round cells, which infiltration was especially marked around the blood vessels in the adventitial sheath. This perivascular infiltration continued along the vessels into the cortex of the brain. In the brain substance were here and there small foci formed by accumulation of round cells, and small hæmorrhages were of common occurrence. On the whole, the grey matter of the large basal ganglia of the brain was more severely affected than the other parts of the brain, and the perivascular infiltration in the adventitial coat was most pronounced.

In the *medulla oblongata* a well marked perivascular infiltration around the congested vessels was present, and the grey substance contained numerous foci of infiltration, the cells consisted of leucocytes, lymphocytes and round cells, and there were numerous small hæmorrhages. Many of the nerve cells appeared shrunken, and possessed a darkly-staining, irregular nucleus.

The spinal cord showed the severest and most widespread lesions. There were, especially around the nerve cells of the anterior horn, accumulation of cells, leucocytes and lymphocytes; the nerve cells appeared in various stages of degeneration. Throughout the grey matter there was a more or less marked general small cell infiltration. Hæmorrhages of different extent were frequently seen, not only in the grey matter, but also in the adjoining white matter. Many of the vessels were surrounded by a thick mantle of round cells, which infiltration was continuous with that of the vessels of the pia-arachnoid space.

Sections of the cerebellum did not show any lesions.

The organs such as heart, muscle, lungs, liver, kidney, lymph glands did not show any striking pathological changes.

A piece of the lumbar part of the spinal cord was ground up in saline solution and injected after trephining into the brain of a second monkey (*Cercopithecus ? sp.*). This animal showed definite signs of illness on the third day after inoculation, remained crouching in a corner, and refused all food. On the fifth day the animal was unable to walk, but still sat up in a corner of the cage. Diarrhœa set in on the following day, and the animal succumbed on the seventh day after inoculation, to an acute attack of gastro-enteritis.

Brain and spinal cord did not show any macroscopical nor microscopical lesions. The mucous membrane of the large intestine was hyperæmic and œdematous.

Another monkey—*Cercopithecus*—(Monkey 2 of Chart VI.), which had been in the animal house for

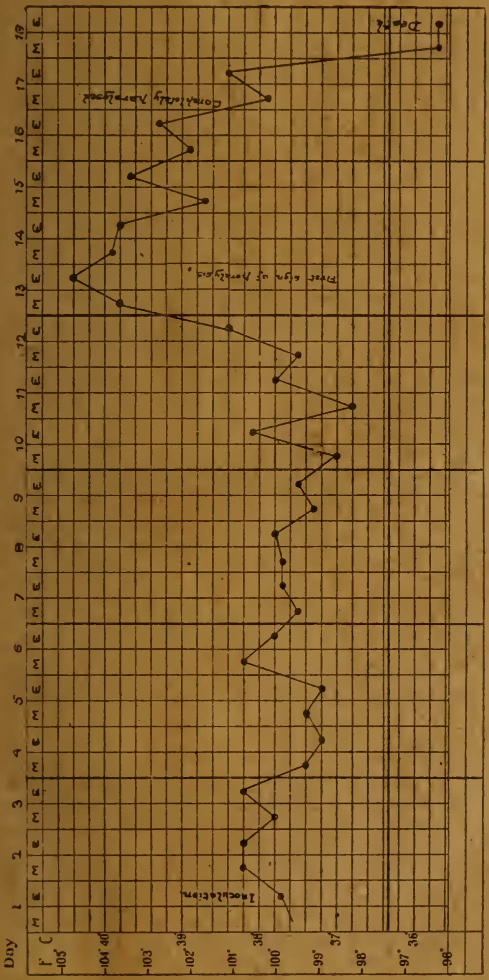

Chart VI.

nearly four years, was inoculated with 0.5 c.cm. of a solution of crushed spinal cord of Case 8 on January 2, 1918. This animal remained absolutely normal until the morning of January 14, when his temperature was raised (*see* Chart VI.), and he began to show signs of weakness in his hind legs. Up to this time he had remained active and jumping about, but now he walked slowly, and showed slight tremors of his leg muscles; his appetite, however, was still normal. The following day the tremors were more pronounced, and both arms began to show signs of paresis.

On January 16 the animal could only sit up for a short time, falling over on his side; the muscles of the legs were tremulous, and both legs were completely paralysed. The following day he had difficulty in swallowing. When disturbed his whole body trembled. His general condition became gradually worse; he remained lying on his side, began to emaciate, and the paralysis of his legs and arms became complete. The body temperature was normal on the 18th and subnormal on the 19th. As it seemed unlikely that the animal could survive the night, it was killed by means of chloroform and an autopsy performed.

At the post-mortem the meninges of the brain appeared markedly hyperæmic on cross-section; the brain substance was soft, œdematous, and congested, showing numerous hæmorrhages, especially in the large basal ganglia.

The meninges of the spinal cord resembled those of the brain. On cross-section the central canal was plainly visible. The grey substance appeared of a greyish-pink colour, and small hæmorrhages were distinctly visible.

The other organs did not show any pathological lesions.

Pieces of the organs were again preserved in formalin, imbedded in paraffin, and sections prepared for microscopical examination.

The microscopical lesions seen in the sections of the brain and spinal cord of this animal were the same as those observed in the monkey which had been inoculated successfully with the spinal fluid of Case 4, as described above. The meninges of the brain and spinal cord were diffusely infiltrated with round cells. There was a slight but diffuse infiltration of the grey substance of the brain, and a well marked perivascular infiltration, especially pronounced around the blood vessels of the grey matter below the ependym of the ventricles.

The grey substance of the spinal cord showed diffuse and focal infiltration, degeneration of the nerve cells and neuronophagia, which varied greatly in severity in the different segments, and was on the whole most pronounced in the lumbar region.

The perivascular infiltration was well marked, and small hæmorrhages were not of rare occurrence.

Sections through kidney, liver and spleen did not show any pathological alterations.[1]

Discussion.

The foregoing clinical histories of nine cases observed in the Townsville Hospital prove conclusively that the disease in question did not differ in any essential clinical aspect from that occurring about the same time in various parts of Queensland and New South Wales.

The patients, mostly children, showed for a few days previously headache and other signs of malaise, or they were suddenly, without any premonitory warning, attacked by convulsions and a high fever, soon afterwards passing into a state of coma, which lasted for two or more days, and a large percentage finally died with signs of hyperpyrexia (the highest temperature recorded was 42.4° C.) and of respiratory failure. Neither Babinski's nor Kernig's sign was constant, the patellar reflexes were exaggerated, head retraction was marked in some cases, but absent in others. Nystagmus was present now and again. Several of the patients had tremors of the arms and legs; others suffered from frequent and violent convulsions affecting sometimes arms and legs only, or simultaneously the muscles of the trunk; several patients showed true opisthotonos.

Intestinal disturbances were not uncommon; the motions were sometimes greenish, slimy and offensive or constipated. Of the two patients who recovered, only one exhibited definite signs of paralysis of one side, from which he recovered in a very short space of time.

Lumbar puncture performed in nearly all cases yielded a clear cerebro-spinal fluid, apparently not under increased pressure; on centrifugalization it showed only a slight increase in its cellular content.

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[1] It seems of interest to record here that 0.5 c.cm. of the blood of a patient suffering from the "mysterious" disease, who subsequently developed complete paralysis of both arms and legs, was inoculated on the fifth day of the disease intracerebrally into a monkey, without causing any symptoms.

The only symptoms constantly present were the onset with convulsions and high temperature, which symptoms were followed by a state of deep unconsciousness, signs which point to an intense irritation of the whole of the central nervous system.

Somewhat similar clinical symptoms may be observed in cases of epidemic cerebro-spinal meningitis, but a lumbar puncture in these cases enables a definite diagnosis to be made. Lead poisoning, in some seasons not a rare disease, may give rise to convulsions, but in no instances have prolonged high temperatures been observed; moreover, in lead poisoning other symptoms, such as the blue line of the gum, the colic-like pains in the epigastrium and the finding of lead in the urine, allow of the verification of the diagnosis.

In the earliest stages, and especially in patients who died within two days, a differential diagnosis from convulsions due to gastro-intestinal disturbances is well-nigh impossible, as in these cases the temperature may rise suddenly, which rise may be quickly followed by violent convulsions; in several of the cases under observation the motions were greenish, slimy and offensive. But convulsions due to gastro-intestinal disturbances yield, in most cases, readily to vigorous treatment, and are not followed by a long lasting state of deep coma.

Of the diseases of the nervous system which mainly attack children in their early infancy the most important is acute poliomyelitis.

Widespread epidemics which occurred at different times in different localities, and especially large epidemics in America, promoted a detailed clinical study of this interesting disease, and brought to light a number of new facts, especially the absence of paralysis in a percentage of cases, which symptom had hitherto been considered the most important diagnostic sign. Peabody and his collaborators pointed out that, "while not many years ago paralysis was regarded as the essential feature, the one important element of the picture, and the accompanying general symptoms, were more or less disregarded, the tendency of present medical thought is towards the conception of poliomyelitis as an acute infectious disease which often leaves in its wake a variety of disabling end results."[11]

And when we compare the clinical symptoms of our cases with the symptoms of the "cases of acute poliomyelitis with deep stupor," also termed "cerebral or encephalitic, in which drowsiness preponderates in the early days and gradually deepens into stupor," the similarity is striking, but this type of case is seemingly rare and impossible to diagnose unless paralysis appears. One of our patients who recovered (Case 6) showed hemiplegia, others died before paralysis could have become established.

In these cases only microscopical examination of the central nervous system and the successful inoculation of the virus into monkeys can place the diagnosis beyond doubt.

Of the seven fatal cases, the brain and spinal cord were examined. Four showed lesions typical of acute poliomyelitis, not only affecting the spinal cord, but showing an extensive involvement of the grey matter, and also to a certain extent of the white matter of the brain. The *pia mater* of the brain and spinal cord showed diffuse and perivascular cell infiltration of varying degree, which extended with the vessels into the surface layer, and appeared around the blood vessels of the grey substance, where these blood vessels were distended and filled with red blood corpuscles. The grey substance showed a diffuse infiltration with leucocytes and round cells, and here and there a greater number of these cells were collected into small foci, the grey matter around appearing softened.

The ganglion cells showed changes, varying from the earliest stages of degeneration to complete disappearance. Many of them were surrounded by leucocytes, lymphocytes and large mononuclear cells, possessing a large, irregular nucleus, with a fine chromatin network—a process known as neuronophagia.

In three cases (2, 3 and 5), which were clinically in every essential respect identical with the others (1, 4, 7 and 8), the only lesions found were a slight but diffuse infiltration, mainly of the grey matter of the brain and spinal cord, which was present, although to a much less degree, in the white matter; here and there were numerous hæmorrhages of varying extent.

The microscopical lesions of our cases are identical with the lesions described by numerous observers—lately by Blanton[12]—as occurring in fatal cases of acute poliomyelitis. They differ pathologically in one respect only, namely, in the extensive involvement of the brain. Small scattered lesions are not uncommonly encountered as autopsy findings in the brain of fatal poliomyelitis cases; the occurrence of extensive cerebral involvement has, however, rarely been demonstrated previously, and it has, in the opinion of Peabody and his collaborators, as yet not been shown that the virus of poliomyelitis exists in typical polio-encephalitis by transference of the disease to monkeys.

The two successful monkey experiments furnish conclusive proof that the virus of two cases (4 and 7) suffering from acute poliomyelitis and polio-encephalitis, which were clinically indistinguishable from the other cases of the "mysterious disease," caused, when inoculated intracerebrally into monkeys, identically the same symptoms and pathological lesions in these animals, as the virus derived from undoubted cases of poliomyelitis.

The conclusion is therefore justified that the cases of "mysterious disease" occurring in Queensland and New South Wales are caused by the same virus as acute poliomyelitis. The disease differs pathologically only in one respect from typical acute poliomyelitis, namely, in the extensive involvement of the brain; the peculiar clinical aspect seems to have, till now, eluded observation.

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STUDIES IN AUSTRALIAN TABANIDÆ

BY

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The following paper is the result of an examination of the Tabanidæ in the Australian Museum, Sydney, which comprises one hundred and twelve specimens representing forty-six species and four varieties referable to seven genera.

Twelve species and four varieties are described as new, while the males of *Erephopsis cinerea*, Ricardo, *Diatomineura pulchra*, Ricardo, and *Tabanus postponens*, Walker, are also described for the first time. Notes on previously known forms are added where necessary.

The new species are distributed in the following genera :—*Erephopsis* (two and one var.), *Diatomineura* (three), *Pelecorhynchus* (two), *Silvius* (one), *Ectenopsis* (one var.) and *Tabanus* (four and two vars.).

One synonym is noted and one name is changed, on the grounds of priority, though they have no connection with the material under review.

The type specimens are in the Australian Museum. One paratype is in the Institute Collection.

This paper brings the number of known Australian Tabanidæ to one hundred and eighty-eight species and five varieties, which are distributed in fifteen genera.

I wish to thank the Trustees and Mr. R. Etheridge, Junr., Director and Curator, of the Australian Museum, for giving me the opportunity to study these forms.

Sub-family PANGONINÆ.

PELECORHYNCHUS DISTINCTUS, *sp. nov.*

♀. Length, 14; width of head, 4.5; length of wing, 13.2 mm.

A handsome well-marked species easily identified by its warm black thorax with lateral yellowish-brown stripes; thorax bright orange-rufous with a median black stripe. Legs reddish-yellow, tarsi paler. Wings with dusky brown and orange spots.

Head.—Face and cheeks buff, the former very convex, with a short median dark stripe, an almost quadrate brown blotch beneath the stripe and with a larger nude reddish-brown patch on either side of the apex of the middle third, grooves separating face and cheeks deep; pubescence long, mixed black and white, the latter more numerous basally; beard white, dense; front buff, ocellar triangle and base of antennæ dusky brown, pubescence on ocellar triangle black, long; first joint of antennæ black, with long brownish pubescence, second joint yellowish, third joint bright orange-rufous; palpi pale reddish-yellow, second joint with long white pubescence; eyes black, bare; proboscis dark brown.

Thorax.—Warm black with a sub-median and lateral pale yellow ochre stripe on each side, the former continued to posterior margin of the scutellum; pubescence black, pale on the sides, white beneath the shoulders, beneath and behind the wing roots; scutellum warm black in the centre, pale yellow-ochre elsewhere, posterior pubescence white on the sides, brownish in the middle; pleuræ black with grey pubescence.

Abdomen.—Orange-rufous with a median black stripe extending to the middle of the penultimate segment, lateral margins widely reddish-brown, dark brown on the first segment; venter dark reddish-brown, lateral pubescence white, long.

Legs.—Femora and tibiæ reddish-yellow, tarsi warm buff; pubescence reddish-yellow, paler on the tarsi.

Wings.—Dusky brown with the upper half deeper hued, the apex of the radial, the cubital cell and portion of the apex of the apical cell clear, with clear patches in the first, second, fourth and fifth posterior cells, the discoidal, anal and the auxiliary cells, with an orange spot reaching from the costa through the subcostal into the cubital cell; veins brown; no appendix present; halteres dark brown.

Obs.—Described from two specimens. This species belongs to the *fulvus-mirabilis* group of *Pelecorhynchus*, but may be readily separated from *P. mirabilis*, Taylor, by its different facial and thoracic markings and the color of the legs. It may be distinguished from *P. fulvus*, Ricardo, by the *russet* colored thorax, abdomen and wings, and by the black legs with yellow tarsi.

Hab.—Dorrigo, New South Wales. (Collector and donor.—R. J. Tillyard).

PELECORHYNCHUS TILLYARDI, *sp. nov.*

♀. Length, 16.5; width of head, 5; length of wing, 13 mm.

A striking species owing to its black color. First and second joints and base of third joint of the antennæ black; the next four annuli warm-buff, and remaining annuli black. Wings black. First and second abdominal segments with dense white pubescence.

Head.—Face, cheeks and front black with grey tomentum, pubescence black; beard black; groove between face and cheeks deep; palpi black, pubescence black, long; antennæ with the first two joints and base of third black, next four annuli warm buff, remaining annuli black; pubescence on the first two joints black, scanty; ocelli prominent.

Thorax.—Black with two broad median grey stripes terminating at the posterior margin of the thorax with a short wedge-shaped black stripe in each grey one from the posterior margin of thorax and a narrow black stripe separating the grey ones; pubescence black, lateral pubescence long and a tuft of white hairs behind the wing roots; pleuræ black with black pubescence.

Abdomen.—Black, first segment with dense white pubescence, except in the centre, where it is black, second segment with a basal lateral triangular patch of white pubescence, remaining segments shining black, pubescence black, fairly long on sides of fourth segment; venter black with black pubescence.

Legs.—Black, pubescence black, fairly long on the femora.

Wings.—Black, veins black, all cells open, no appendix.

Obs.—Described from a single specimen which is abundantly distinct from all other known species of *Pelecorhynchus* on account of its general colour. It affords me great pleasure to dedicate this handsome species to its discoverer.

Hab.—Dorrigo, New South Wales. (Collector and donor.—R. J. Tillyard)

PELECORHYNCHUS FUSCONIGER, *Walker.*

List. Dipt., i. (1848), p. 192 [? Silvius] et. v., Suppl. l. (1854), p. 267, [Dasybasis]; Ricardo, Ann. Mag. Nat. Hist. (8), v. (1910), p. 407.

Hab.—Woodford, New South Wales.

PELECORHYNCHUS NIGRIPENNIS, *Ricardo.*

Ann. Mag. Nat. Hist. (8), v. (1910), p. 405.

Obs.—This appears to be a widely distributed species being found from Southern Queensland to Tasmania.

Hab.—Ebor, New South Wales. (Collector and donor.—R. J. Tillyard); Stradbroke Island, Queensland. (Collector.—J. C. Bridwell).

EREPHOPSIS CINEREA, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 26.

♂. Length, 11; width of head, 4.5; length of wing, 10; proboscis, 4 mm.

Lower third of eyes with small facets; antennæ blackish-brown, first two joints with long black hairs; palpi black with second joint slightly longer than the first, ending in a blunt point, pubescence black, a dirty white at base of first joint.

Thorax.—Lateral borders with long black pubescence, and long white hairs from wing roots to scutellum.

Abdomen.—First segment clothed with grey pubescence, sides of second to sixth segments with apical grey pubescence.

Obs.—A very distinct species, the long stem of the first posterior cell and the large stigma being very distinctive.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

EREPHOPSIS NEOTRICOLOR, *sp. nov.*

♀. Length, 10.5-11; width of head, 4; length of wing, 10.5; proboscis, 5.5-6 mm.

A small species with black thorax, brown abdomen with median stripe; the cross-veins shaded brown and with brown legs.

Head.—Face convex, reddish-brown, cheeks darker with grey tomentum, pubescence black; front black, tomentum ashen, vertex about half as wide as base, pubescence black, no frontal callus; eyes covered with dense pale pubescence; antennæ red, first two joints paler than third with long black pubescence, apex of third black; palpi red, second joint concave and longer than first, pubescence black; beard dense, creamy-white; proboscis long, black.

Thorax.—Black, clothed with mixed, erect black and scattered appressed golden hairs, lateral borders with long black and cream colored hairs and pale ones behind the wing roots; scutellum similar to thorax; pleuræ black, covered with pale pubescence.

Abdomen.—Reddish-brown, the fourth to the apical segments blackish, segmentations pale, segments one to three with median square black spots not reaching the posterior borders, all segments with traces of median pale apical hairs, pubescence black, golden on the segmentations and at the sides; venter reddish-brown, pubescence yellowish.

Legs.—Coxæ black with long pale pubescence, femora and tibiæ reddish-brown, tarsi darker, pubescence black.

Wings.—All the cross-veins shaded brown, the cells on the inner half of the wing mainly clear, rest slightly tinged with brown; stigma yellow; a small appendix present; the first posterior cell closed a short distance from the border.

Obs.—A small species closely related to *E. tricolor*, Walker, but may be separated from it by its different front, abdomen and wings. It is also close to *E. doddi*, Ricardo, but differs in the thorax, legs and wings.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

EREPHOPSIS GEMINA, *Walker.*

List. Dipt., i. (1848), p. 138; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 24.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

EREPHOPSIS GIBBULA, *Walker.*

List. Dipt, i. (1848), p. 140; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 22.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

EREPHOPSIS SUBMACULA, *Walker.*

List. Dipt., i. (1848), p. 142; Ricardo, Ann. Mag. Nat. Hist. (7), v. (1900), p. 115.

Represented by a single specimen, which agrees fairly well with Ricardo's description. The face lacks the black square mark above the palpi; the first three abdominal segments have lateral white pubescence, very pronounced on the first and reduced to a small patch on the third; venter with interrupted white bands on the second to fourth segments.

Hab.—Western Australia.

EREPHOPSIS MACULIPENNIS, *Macquart.*

Dipt. Exot., Suppl. iv. (1849), p. 20; Ricardo, Ann. Mag. Nat. Hist. (8), xix. (1917), p. 209.

A ♂ specimen labelled as above shows some discrepancies both from the original and Miss Ricardo's descriptions in as much as the black spots on the abdomen, which is entirely testaceous, are absent, as is also the appendix on the wing. First two joints of the antennæ red-brown, the third reddish-yellow, apex darker. The beard is tawny.

Hab.—South Australia.

EREPHOPSIS LASIOPHTHALMA, *Boisduval.*

Voy. "Astrolabe," Zool. ii. (1832), p. 666, [Pangonia]; Ricardo, Ann. Mag. Nat. Hist. (8), xix. (1917), p. 210.

Obs.—Four specimens agree very well with Miss Ricardo's description of this species. They show that the narrowing of the first posterior cell at the border is a variable character — one specimen has it barely closed on one wing, on the other wing the first posterior cell has a distinct petiole. Another specimen shows a distinct petiole to the first posterior cell on both wings.

Hab.—Moonbar and Jindabyne, New South Wales. (Collector.—R. Helms).

EREPHOPSIS VICINA, *sp. nov.*

♂. Length, 14; width of head, 5.5; length of wing, 14; proboscis, 5 mm.

A species with clear wings; thorax with five grey stripes; abdomen mainly reddish-brown with black spots in the middle of the second and third segments and lateral golden pubescence on the thorax and abdomen; legs reddish-brown.

Head.—Face and cheeks covered with grey tomentum and long grey hairs mixed with scattered black ones; beard orange; first joint of antennæ swollen, long, black, base red-brown, second joint dark red-brown, base of third red-brown, annuli black, pubescence on first two joints black, long and dense; palpi black, second segment considerably longer than first, tapering to a blunt point, apex reddish, pubescence creamy-white, dense; proboscis black; eyes covered with dense black pubescence.

Thorax.—Black, reddish-brown above wing roots, with three grey stripes on the anterior half and one on either side above the wing roots on the posterior half; pubescence on lateral borders black on the anterior half and a dense row of orange hairs beneath the black ones the whole length of the thorax, there is a tuft of grey hairs behind the wing roots; scutellum black; pubescence black; pleura with grey tomentum and pubescence.

Abdomen.—First segment black, sides red-brown, second red-brown with an apical lateral patch, third black with red-brown flecks, fourth and fifth black, segmentations red-brown; second segment with a median black spot, segments one to three with traces of orange hairs medianally, lateral pubescence orange; venter black, segmentations red-brown, pubescence grey and black, that on segmentations pale, yellowish towards apex.

Legs.—Coxæ blackish with grey pubescence; femora, tibiæ and tarsi red-brown, pubescence black, grey on upper surface of femora.

Wings.—Clear, basal half of fore border and base yellowish, cross-veins at base of third vein and discal cell tinged brown; veins dark brown, stigma yellow; no appendix.

Obs.—A species most nearly related to *E. aureohirta*, Ricardo, but differs in the color of the antennæ, palpi and legs, and the ornamentation of the thorax and abdomen.

Hab.—Wentworth Falls, New South Wales. (Collector and donor.—A. Musgrave).

Var. GEORGII, *var. nov.*

♀. Similar to the type but the beard is yellow instead of orange; the lateral fringe of orange hairs on the thorax and abdomen is replaced by yellow ones, with black ones above on the abdominal segments, longest on the third and fourth segments.

The front is about one third broader anteriorly than at vertex and black with black pubescence; first two joints of antennæ dusky-brown, rest red-brown; palpi black, second joint red-brown above, concave, ending in a fine point; basal half of femora black. The spot on the wing is also more prominent.

Obs.—The above differences, in the absence of fresh material, do not, to my mind, warrant the variety being raised to specific rank.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

EREPHOPSIS JACKSONI, *Macquart.*

Dipt. Exot., i. (1838), p. 102; Ricardo, Ann. Mag. Nat. Hist. (7), v. (1900), p. 117.

Obs.—Two specimens before me may probably belong to this species. One specimen bears label "*Erephopsis ? jacksoni, Mcq.*" in Miss Ricardo's handwriting.

The Queensland specimen is somewhat abraded, but I am unable to separate it specifically from the Western Australian form.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters); Queensland.

DIATOMINEURA JACKSONENSIS, *Guèrin.*

Voy. de la "Coquille," ii., pt. 2 (1830), p. 289; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 27.

Obs.—A specimen in the collection agrees too closely with the description of this species to separate it specifically in the absence of more numerous material.

Hab.—South Australia.

DIATOMINEURA GAGATINA, *Bigot.*

Mém. Soc. Zool. Fr., v. (1892), p. 620; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 33.

Obs.—I identify three specimens as the above species which agree in all esentials with Miss Ricardo's decription. There is a prominent tuft of orange-colored hair beneath the wing roots of which no mention is made in the descriptions.

Hab.—Gayndah, Queensland. (Collector.—G. Masters); Magnetic Island, Cleveland Bay, Queensland. (Collector.—F. H. Taylor).

DIATOMINEURA CYDISTER, *sp. nov.*

♂. Length, 11.5-12; width of head, 4; length of wing, 9.5 mm.

A small handsome blackish species with reddish-yellow markings on the abdomen; antennæ, palpi and thorax black; legs black and reddish-brown; wings shaded brown on fore border; abdomen dark chocolate brown.

Head.—Face, and cheeks black, pubescence black and cream colored, the former mainly on the cheeks; beard cream-colored; antennæ black, first two segments with grey tomentum and black pubescence, base of third oblong, its sides parallel, its base reddish-brown; palpi black, with long black pubescence; eyes black, pubescence black.

Thorax.—Black with indications of two submedian grey stripes, one on either side, lateral borders with black pubescence, pale behind the wings; pleuræ black, tomentum and pubescence grey; scutellum dark chocolate brown.

Abdomen.—Dark chocolate brown, pubescence dark, pale on the segmentations, all the segments with reddish-yellow, lateral, posterior blotches, with pale pubescence, smallest on the last three segments; venter reddish-brown, pubescence pale.

Legs.—Coxæ, femora and tarsi black, basal half of tibiæ reddish-brown, rest black; pubescence on coxæ and femora above at base pale, elsewhere black.

Wings.—Grey, veins on fore half and cross-veins at base of discal cell shaded brown, except anterior branch of third vein; first posterior cell widely open at border; no appendix; stigma brown; halteres black.

Obs.—A very distinct and striking species on account of its abdominal ornamentation. One of the two specimens bears a label by Miss Ricardo "*Diatomineura sp.*, near *gemella*, Wek."

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

DIATOMINEURA PULCHRA, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 35.

♂. Length, 9.5; width of head, 3.5 (vix); length of wing, 9; proboscis, 2 mm.

Head.—Face and cheeks covered with yellow tomentum and mainly black with scattered yellow pubescence; face with a deep median furrow, the groove deep between the face and cheeks: palpi orange-yellow, first joint short, swollen, less than half the length of the second which ends in a blunt point; pubescence scanty, yellowish; first two joints of antennæ with yellow tomentum and black pubescence; pubescence on eyes pale on the sides, dark elsewhere.

Thorax.—Similar to that of the female.

Abdomen.—Similar to ♀, but the golden-yellow haired stripe is also present on the first two and fifth segments in addition to the third, fourth and sixth segments.

Legs.—Reddish-yellow, tarsi darker, femora appear yellow in some lights; pubescence black.

Wings.—Greyish, first posterior cell not narrowed at the border.

Obs.—This specimen is labelled by Miss Ricardo as "perhaps the undescribed ♂ of *D. pulchra*, Ric." It is so similar in appearance to the ♀ that I describe it as such.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

DIATOMINEURA BREVIROSTRIS, *Macquart.*

Dipt. Exot., Suppl. iv. (1842), p. 326; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 28.

Obs.—The South Australian specimens were identified by Miss Ricardo—the Long Flat specimens are identical.

Hab.—South Australia. Long Flat, Hastings River, New South Wales; (Collector and donor.—A. R. McCulloch).

DIATOMINEURA REGIS-GEORGII, *sp. nov.*

♀. Length, 9.5-10; width of head, 3.25-3.5; length of wing, 9.5-10; proboscis, 4.5 mm.

Head.—Face convex, creamy, pubescence creamy; cheeks greyish, tinged creamy, pubescence creamy; groove between face and cheeks deep; front about twice as wide anteriorly, tomentum grey-brown, pubescence dark; no frontal callus; pubescence on eyes dark, pale on outer margin; first two joints of antennæ pale reddish-yellow, pubescence black, third joint red; palpi deep yellow, upper margin of second joint concave, reddish, pubescence black; proboscis black, long; beard grey, dense.

Thorax.—Black, tomentum grey, pubescence golden, lateral black, a tuft of grey pubescence beneath and behind the wing roots; scutellum black, posterior border with long golden pubescence; pleuræ black, tomentum and pubescence grey.

Abdomen.—The centre of the first and second segments and the posterior border black, remainder yellowish-brown, remaining segments black, posterior segmentations yellowish-brown; pubescence black, golden on the segmentations; venter yellowish-brown, flecked with black, pubescence pale.

Legs—Coxæ, femora, and tibiæ yellowish-brown, tarsi darker, coxæ with pale pubescence, that on femora pale above and black beneath, tibiæ and tarsi with black pubescence.

Wings.—Clear, veins yellowish-brown; stigma inconspicuous; first posterior cell slightly narrowed at the border. Halteres pale.

Obs.—Described from two almost perfect specimens and unlike any other *Diatomineura* known to me and does not fit the descriptions of other species. It is somewhat similar in build to *Erephopsis gibbula*, Walker.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

DIATOMINEURA BICOLORATA, *sp. nov.*

♂. Length, 11, ♀ 11; width of head, ♂ 4, ♀ 4 (vix); length of wing, ♂ and ♀, 10.75; proboscis, ♂ 5, ♀ 4.75 mm.

A small compact species. Antennæ and palpi reddish-yellow; thorax black; abdomen yellowish-red; apical segments black; legs reddish-brown; wings with cross-veins shaded.

♂. *Head.*—Face reddish-yellow, convex, pubescence black and pale, dense; cheeks with grey tomentum and dark pubescence, groove between cheeks and face shallow; first two joints of antennæ pale reddish-yellow with long black pubescence, third joint red, apex black; palpi yellowish-brown, first joint short, swollen, second joint tapering to a fine point, pubescence at apex black, elsewhere yellow; beard yellowish, dense; eyes densely pubescent.

Thorax.—Black, reddish above the wing roots, tomentum brown, pubescence yellow and black, dense; lateral borders with black pubescence, orange above the wing roots; scutellum similar to thorax; pleuræ with grey-brown tomentum and grey pubescence, orange colored beneath the wings.

Abdomen.—First three segments yellowish-red, third flecked with black, remaining segments black, segmentations yellowish-red, second and third segments with median, oblong, dark brown plugs, pubescence black, lateral pubescence on first three segments orange mixed with black, black on fourth, cream colored on remaining segments; venter with basal portion pale yellowish with a median, narrow, black stripe, rest black, pubescence mixed pale and black.

Legs.—Reddish-brown, coxæ and tarsi darker, pubescence black, very long on under surface of femora.

Wings.—Posterior half shaded yellowish-brown; cross-veins at the apex and base of the discal cell and the base of the anterior branch of the third long vein shaded brown, rest of wing grey; stigma pale, inconspicuous; appendix rudimentary.

♀. Similar to the ♂. First joint of the palpi hidden by pubescence, second reddish-yellow, concave on upper margin, ending in an obtuse point Front black, tomentum ash-grey, pubescence black, vertex about half the width of the base, no callus present.

Obs.—A species related to *D. regis-georgii*, Mihi, but distinguished from it by the shaded posterior border and cross-veins of the wings and the different abdomen. The clothing on the pleuræ of the thorax is also brighter.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

DIATOMINEURA PLANA, *Walker.*

List. Dipt., i. (1848), p. 144; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 32.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

DIATOMINEURA TESTACEA, *Macquart.*

Dipt. Exot., i. (1838), p. 103; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 31.

Hab.—South Australia.

DIATOMINEURA CONSTANS, *Walker.*

Dipt. Saund., i. (1850), p. 15; Ricardo, Ann. Mag. Nat. Hist. (8), xix. (1917), p. 208.

Hab.—Tasmania.

DIATOMINEURA INFLATA, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 34.

Hab.—Hastings River, (Collector and donor.—A. R. McCulloch); Coomeroo, New South Wales.

Mr. Tillyard has also taken this species at Kendall, New South Wales.

CORIZONEURA CHRYSOPHILA, *Walker.*

List. Dipt., i. (1848), p. 155; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 36.

Hab.—Sydney, New South Wales. (Collector and donor.—E. P. Ramsay).

CORIZONEURA FULVA, *Macquart.*

Dipt. Exot. Suppl., iv. (1850), p. 19; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 36.

Obs.—One of the specimens is ticketed "Australia."

Hab.—Sydney, New South Wales.

SILVIUS AUSTRALIS, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 263.

Obs.—A single specimen contained in the collection does not allow of definite determination on account of its poor state of preservation, but it is almost certainly this species.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

SILVIUS FERGUSONI, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xix. (1917), p. 214.

A ♀ specimen contained in the collection does not altogether agree with Miss Ricardo's description in that the eyes are thinly pubescent. The abdomen has median white triangular spots on segments one to four inclusive with faint grey tomentose banding on segments three and four and broad apical lateral spots on segments two to four. The sub-callus also bears a deep median longitudinal groove. The wings are uniformly blackish-brown; a small appendix present. Length, 14 mm.

Obs.—It is considered inadvisible to more than make the above note until the specimen has been compared with an authentic specimen of *S. fergusoni*, Ricardo.

Hab.—Norton's Basin, Nepean River, New South Wales. (Collector and donor.—A. Musgrave).

SILVIUS MINOR, *sp. nov.*

♂. Length, 10-10.5; width of head, 3-3.5; length of wing, 10 mm.

A small brown species with spotted wings. Thorax, abdomen and legs reddish-yellow.

Head.—Face, reddish-yellow, cheeks darker, pubescence black with a few pale scattered hairs; beard grey, scanty; antennæ golden yellow, apical annuli red-brown, second segment about half the length of the first, pubescence black, scanty; first joint of palpi yellowish, very short, swollen, second joint long, slender, ending in a blunt point, about four times the length of the first, pubescence black; eyes bare; ocelli prominent.

Thorax.—Black, covered with yellowish-brown tomentum and pale pubescence, lateral borders with pale pubescence; scutellum paler than thorax, posterior border with pale pubescence; pleuræ dark yellowish-brown, pubescence pale.

Abdomen.—Uniform dark yellowish-brown, with indistinct grey tomentose bands, pubescence pale: venter similar to dorsum.

Legs.—Coxæ reddish-brown; femora, tibiæ and tarsi honey-yellow, pubescence pale.

Wings.—Tinged brown, with darker spots at the base and apex of the discoidal and apex of the inferior basal cells, these cells, the anal and the axilliary cells almost clear; veins brown; stigma brown, inconspicuous; no appendix present.

Obs.—The thorax of the two specimens before me is more or less abraded but sufficient thoracic clothing remains in the type to show its nature. It is a very distinct species and may be separated from *S. doddi*, Ricardo, and *S. lunulatus*, Bigot, by its thorax, abdomen, legs, wings; the palpi are also distinctive.

Hab.—South Australia.

SILVIUS NIGRIPENNIS, *Ricardo.*

SILVIUS ATER, *Taylor.*

Ann. Mag. Nat. Hist. (8), xix. (1917), p. 213; Taylor, Proc. Linn. Soc., N. S. Wales, xli. (1917), p. 751.

S. nigripennis takes precedence as it appeared in February whilst *S. ater* was not published until April.

Hab.—Claudie River, Queensland. (Collector.—J. A. Kershaw); Brock's Creek and Mary River, Northern Territory. (Collector.—G. F. Hill).

SILVIUS DODDI, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 261.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

ECTENOPSIS AUSTRALIS, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xix. (1917), p. 217.

Length, ♂ 11.5, ♀ 10.5-11; width of head, ♂ 3.5, ♀ 2-2.5; length of wing, ♂ 10, ♀ 10-10.5 mm.

Two ♀ specimens and a ♂ in the collection differ somewhat from the description of this species which is stated to be somewhat variable in the legs.

♂. Abdomen as in description; legs black, except basal half of femora reddish-yellow, *femur, tibiæ and first tarsal of the middle right leg pale reddish-yellow*, remaining tarsi dusky; antennæ as described, third joint missing.

♀. Second and third divisions of antennæ raw-sienna; median thoracic stripe uniformly broad, broader than the lateral stripes; no triangular median spots on the second to fourth segments of abdomen; appendix of wing variable in length; legs as in type.

Obs.—Judging from the description of this species and the specimens before me this would appear to be a variable species. The differently colored mid right leg in the ♂ is curious as it belongs without doubt to the specimen under review. The dimensions of these specimens is given as they were omitted from the description of the type.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

ECTENOPSIS VULPECULA, *Wiedemann.*

Ausszweifl. Ins. i. (1828), p. 195 (Chrysops); Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 266.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

Var. NIGRIPENNIS, *var. nov.*

♀. Length, 11; width of head, 3; width of front of vertex, 0.5; length of wing, 9.5 mm.

Palpi black, base raw-sienna, pubescence black, beard very scanty, golden; first and second segments and first two divisions of the third joint of the antennæ reddish-brown, rest black; pubescence black, sparse; wings dusky, veins deep black; stigma black; appendix short. Legs: coxæ raw-sienna, femora, tibiæ and tarsi black, pubescence black.

Obs.—Represented by a single specimen in the collection. It differs from *E. vulpecula*, Wied., in the above details which do not appear to be sufficient to raise it to specific rank. It is abundantly distinct from *E. australis*, Ricardo.

Hab.—Norton's Basin, Nepean River, New South Wales. (Collector.—A. Musgrave).

Sub-family TABANINÆ.

Group vii. Abdomen with one or more stripes, usually continuous.

TABANUS PARVICALLOSUS, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xvi. (1914), p. 394.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

Group viii. Species with median or lateral spots, or both, on abdomen, not usually forming a continuous stripe.

TABANUS SPOLIATUS, *Walker.*

Proc. Linn. Soc., iv. (1860), p. 103; Ricardo, Ann. Mag. Nat. Hist. (8), xv. (1915), p. 275.

Obs.—The collection contains a single ♂ specimen determined as this species by Miss Ricardo from Victoria (no definite locality being given). It seems remarkable that a species described from Macassar, and the Celebes, being unknown from Northern Australia where its presence might be expected, should be found in Victoria.

Hab.—Victoria.

TABANUS VICTORIENSIS, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xv. (1915), p. 275.

Obs.—The collection contains two specimens, one of which, determined by Miss Ricardo, is in rather a poor state of preservation, the thorax and abdomen being abraded. The second specimen is clearly this species and is in a good state of preservation

Hab.—Moonbar, (Collector —R. Helms); Blackheath, New South Wales. (Collector and donor.—A. Musgrave).

Group ix. Species with paler bands, and sometimes spots on abdomen.

TABANUS MUSGRAVII, *sp. nov.*

♀. Length, 11; width of head, 4; width of front of vertex, 0.25; length of wing, 11 mm.

A small compact black species. Antennæ dark reddish-brown, apices black. Palpi reddish-yellow. Thorax black. Abdomen black with grey bands. Legs blackish.

Head.—Face, cheeks and sub-callus grey-black; beard grey, scanty; front black, uniform in width, pubescence black, short and scanty; frontal callus shining black, tumid, pear-shaped, reaching the eyes, with a lineal extension, about as long as the plug, not reaching the vertex; eyes dull black, with copper-colored patches in some lights; antennæ dark reddish-brown, annuli black, tooth very small on expanded basal portion, pubescence black and scanty on first and second segments; palpi reddish-yellow, pubescence black; proboscis very short, black.

Thorax.—Dark grey-black, with short, scanty, mixed dark and pale pubescence, sides with dense, fairly long grey-black hairs; scutellum similar to thorax with some scanty grey pubescence; pleuræ grey-black with fairly long grey hairs.

Abdomen.—Dull black, densely clothed with appressed black hairs, segmentations grey with grey pubescence and faint pale creamy median spots on the first four segments, lateral margins of the first six segments grey, diminishing in size toward the apex; venter grey with whitish pubescence, segmentations distinct.

Legs.—Black, femora with fairly dense and long grey pubescence, black on tibiæ and tarsi, longest on the tibiæ.

Wings.—Grey; veins black; stigma dark yellowish-brown; no appendix.

Type.—Unique. It may be distinguished from *T. kershawi*, Ricardo, by its differently colored antennæ, its sub-callus not shiny, the uniform front and the wings. Differs from *T. griseoannulatus*, Taylor, in its larger frontal callus; the first and second joints of the antennæ being uniform in color and the absence of an appendix on the wings.

Hab.—Underbank, New South Wales. (Collector and donor.—A. Musgrave, Dec. 1915).

TABANUS MACQUARTI, *Ricardo.*

Ann. Mag. Nat. Hist. (8), xv. (1915), p. 277.

Hab.—South Australia.

Group x. Species with the abdomen unicolorous, or almost so, sometimes darker at the apex.

TABANUS DIMINUTUS, *Walker.*

List. Dipt., i. (1848), p. 183; Ricardo, Ann. Mag. Nat. Hist. (8), xv. (1915), p. 285.

Obs.—There seems little doubt that the specimen before me is referable to this species. There are a few points of disagreement with Miss Ricardo's description of Walker's type, but it is said to be in a poor state of preservation. The third joint of the antennæ is blackish-brown instead of tawny and the frontal callus is a small, almost circular, light brown plug without a lineal extension.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

TABANUS SANGUINARIUS, *Bigot.*

Mém. Soc. Zool. France, v. (1892), p. 675; Ricardo, Ann. Mag. Nat. Hist. (8), xv. (1915), p. 287.

Hab.—South Australia.

Group xi. Species with pubescence on the eyes (Therioplectes).

TABANUS IMPERFECTUS, *Walker*.

List. Dipt., i. (1848), p. 179; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 278.

♂. Length, 10; width of head, 3.5; length of wing, 8 mm.

Antennæ, palpi and thorax similar to ♀. Abdomen with a grey basal band on the second segment in addition to the posterior band; tibiæ blackish, first tarsals black. Wings grey; veins and stigma black; appendix present.

Hab.—Wedge Bay, Tasmania. (Collector and donor.—G. H. Hardy).

TABANUS RAINBOWI, *sp. nov.*

♂. Length, 11.5; width of head, 4; length of wing, 10 mm.

A small species with black thorax. Abdomen orange-rufous with a broad black stripe the whole length gradually tapering to the apex. Legs orange-rufous. Wings faintly yellow.

Head.—Face and cheeks black, dark reddish-brown round the base of the antennæ; sub-callus dark reddish-brown; first and second joints of the antennæ reddish-yellow, with dense black pubescence, third joint wanting; palpi light yellowish-brown, second joint swollen and longer than the first, ending in a blunt point; pubescence long and black with a few long grey hairs in addition on the first joint; eyes black, facets small, densely covered with short grey pubescence; beard dense, grey, with scattered black hairs.

Thorax.—Black, clothed with long, erect black hairs; sides orange-rufous, with long black pubescence from the wing roots to the apex of the shoulders; scutellum black, pubescence black: pleuræ black with scattered grey hairs.

Abdomen.—Orange-rufous; first segment black, apical margin orange-rufous, black in the centre, remaining segments, except the last, with large black median spots gradually tapering in width to the apex and forming a continuous stripe, apical segment orange-rufous; pubescence black, golden on the segmentations, the black hairs are long on the sides; venter orange-rufous, pubescence mixed grey and black.

Legs.—Coxæ black, with long black pubescence, basal half of femora black, rest orange-rufous; tibiæ orange-rufous, apices black; fore and mid tibiæ almost wholly black, hind tarsi with the apices black, pubescence black, femora with long grey pubescence beneath.

Wings.—Clear; veins yellowish-brown; stigma yellowish; no appendix present.

Obs.—Described from a single specimen, most nearly related to *T. basalis*, Walker, but may be distinguished by the densely pubescent eyes, the sides of the thorax being orange-rufous, the orange-rufous venter, the legs and the absence of an appendix on the wings.

It affords me much pleasure to associate the name of my friend, Mr. W. J. Rainbow, with this species.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

TABANUS CIRCUMDATUS, *Walker*.

List. Dipt., i. (1848), p. 181; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 280.

Obs.—The West Australian specimens evidently belong to this variable species. When compared with a specimen kindly determined for the writer by Mr. Austen by comparison with the type, the only noticable differences are that the eyes are more hairy and the legs paler.

Hab.—Jindabyne and Moonbar, New South Wales. (Collector.—R. Helms); King George Sound, Western Australia. (Collector.—G. Masters).

TABANUS VETUSTUS, *Walker*.

List. Dipt., i. (1848), p. 179; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 277.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

TABANUS ANTECEDENS, *Walker*.

List. Dipt., i. (1848), p. 178; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 279.

Hab.—Wentworth Falls, New South Wales. (Collector.—A. Musgrave).

TABANUS EDENTULUS, *Macquart*.

Dipt. Exot., Suppl., i. (1846), p. 34; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 281; White, Papers and Proc. Royal Soc. Tasmania (1915), p. 10.

Hab.—Hobart, Tasmania. (Collector.—G. H. Hardy).

TABANUS HOBARTIENSIS, *White*.

Papers and Proc. Royal Soc. Tasmania (1915), p. 13.

Obs.—Represented by a single specimen which does not very well agree with this species, but till further material is available it is considered better to leave it under the above name.

Hab.—Tasmania.

TABANUS NEOBASALIS, *Taylor*.

Tabanus basalis, Walker, ♀, List. Dipt., i. (1848), p. 182, *nomen bis lectum*; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 282.

Obs.—A change of name becomes necessary for this species as *basalis* was previously used by Macquart[1].

TABANUS GENTILIS, *Erichson*.

Archiv. f. Naturgesch., viii. (1842), p. 271; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 286.

Obs.—The specimen from Barrington Tops has the apex of the anal cell slightly shaded brown, but not the stem. It is quite typical in other respects.

Hab.—Barrington Tops, 4,600 ft., New South Wales; (Collector and donor.—A. Musgrave): King George Sound, Western Australia. (Collector.—G. Masters).

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[1] Macquart—Dipt. Exot., i. (1) (1838), p. 130, for a different species belonging to Group vi. from East India.

TABANUS PSEUDOBASALIS, *sp. nov.*

♀. Length, 12.25-13 ; width of head, 4.75-5 ; length of wing, 10-11 mm.

A small black species with pale antennæ and palpi ; thorax black ; abdomen yellowish ; legs reddish-yellow ; wings clear.

Head.—Face and cheeks with creamy-yellow tomentum and pale pubescence ; front paler with golden pubescence, broader anteriorly, about two and a half times as long as broad, no frontal callus ; first two joints of antennæ yellow, pubescence pale, a few black hairs on the apices, third joint bright reddish-yellow, the base with a sharply defined obtuse angle ; palpi cream-colored, tapering to a fine point, pubescence pale, first joint with dense creamy pubescence ; beard cream-colored ; pubescence on eyes very slight.

Thorax.—Black with golden pubescence, shoulders yellowish, lateral pubescence pale ; scutellum similar to thorax, pubescence on anterior border long ; pleuræ pale, flecked with black, pubescence pale.

Abdomen.—Yellowish-brown, darker towards apex, pubescence golden, with scattered black hairs towards the apex ; venter yellowish-brown, tomentum grey.

Legs.—Reddish-yellow, tarsi darker , coxæ with long pale pubescence, short and black elsewhere.

Wings.—Clear ; veins yellow-brown ; stigma yellow ; a small appendix present.

Obs.—This species is in some respects not unlike *T. basalis*, Walker, but it is distinguished by the golden pubescence on the thorax and abdomen, the cream-colored face, the absence of stripe on the abdomen and there being *no* frontal callus.

Hab.—King George Sound, Western Australia. (Collector.—G. Masters).

TABANUS INDEFINITUS, *sp. nov.*

♀. Length, 11-11.5 ; width of head, 4-4.5 ; length of wing, 10 mm.

A small black species with reddish antennæ ; palpi dusky ; thorax black ; abdominal pubescence black, segmentations golden ; legs black, base of tibiæ yellowish ; wings clear.

Head.—Face grey, cheeks buff, pubescence grey ; beard white ; front dark grey, shining black when denuded, pubescence black, vertex black, slightly wider anteriorly ; frontal callus shining black, as wide as front, resting on the sub-callus, and with a short broad extension ; eyes slightly pubescent ; first two joints of antennæ and expanded portion of the third reddish-brown, annuli black, pubescence on first joint pale and black, black on the second, base of third broad, angle small, no tooth ; palpi dark, tapering to a fine point, with dense grey pubescence.

Thorax.—Black with three brown stripes, tomentum grey, densely clothed with erect black and appressed golden hairs, shoulders pale reddish, with black hairs and dense grey ones beneath ; scutellum similar to thorax, posterior border with long golden pubescence.

Abdomen.—Black with black pubescence, posterior borders of segments pale with golden pubescence and median, apical, triangular golden spots on segments one to five, segments broadly pale laterally, second more so than first, and clothed with golden hairs; venter blackish, dark reddish-brown towards the apex, tomentum grey, pubescence pale, golden laterally.

Legs.—Femora and tarsi black, basal two thirds of fore and basal third of hind tibiæ pale reddish-yellow, rest black, mid femora, pale reddish-yellow, pubescence black.

Wings.—Clear, very faintly clouded yellow on the cross-veins at the base of the discal cell; veins dark brown; stigma yellowish, inconspicuous; a long appendix present; base of wings tinged yellow; halteres dark brown, apices yellow.

Obs.—A small but striking species on account of the golden dorsal pubescence. It may be distinguished from *T. antecedens*, Walker, by the thoracic and abdominal ornamentation and the tibiæ. There is also a certain resemblance to *T. oculatus*, Ricardo, in the thoracic clothing but it appears to be distinct.

Hab.—Glenbrook Creek and Norton's Basin, Nepean River, New South Wales. (Collector and donor.—A. Musgrave, Oct. 1915).

Two other specimens also from New South Wales—one from Dunedoo, the other from Sydney may possibly belong to this species but differ in some essentials, and may be characterised as follows:—

Var. A. Antennæ bright reddish-brown, annuli black; palpi paler than in the type; abdomen reddish-brown, except the first and last three segments blackish, segmentations pale; second segment with a median black spot not reaching the posterior margin and segments two to five with indistinct apical grey triangular spots.

Hab.—Dunedoo, New South Wales. (Collector.—W. W. Thorpe, 1/17).

Var. B. Antennæ entirely pale reddish-brown; palpi creamy, and the abdomen similar to Var. A. but lacking the apical triangular spots on the abdomen.

Obs.—I am disinclined to separate these specimens as distinct species in the absence of more specimens, as they resemble the typical form too closely in shape, color of legs and thorax. The wings are also similar to the type.

Hab.—Sydney, New South Wales. (Collector and donor.—A. Musgrave).

TABANUS POSTPONENS, *Walker*.

List. Dipt., i. (1848), p. 179; Ricardo, Ann. Mag. Nat. Hist. (8), xvi. (1915), p. 282.

♂. Length, 13; width of head, 5; length of wing, 12 mm.

Head.—Face and cheeks grey-black, tomentum and pubescence grey; beard white; first two joints of antennæ blackish; pubescence black, third wanting; palpi, first joint dark reddish-brown, slender, second joint swollen, pale reddish-yellow, pubescence mixed pale and black; eyes with dense pale pubescence, facets black and brown, the latter occupying the upper two-thirds, except for a narrow border of black ones circling the eyes above.

Thorax.—Black, partially denuded, with a few scattered black hairs, sides with long pale ones; scutellum similar, posterior margin with pale hairs; pleuræ black, tomentum grey, pubescence pale.

Abdomen.—Reddish-brown, darker toward the apex, the grey tomentose bands narrow with faint indications of median grey triangular spots; venter reddish-brown, segmentations grey.

Legs.—Dusky, base of tibiæ reddish.

Wings.—Clear; veins and stigma yellowish-brown; a small appendix present.

Obs.—Notwithstanding certain discrepancies with the description of this species, which may be sexual, it is considered preferable to place the above specimen under this species. It is the first time the ♂ has been described.

Hab.—Gayndah, Queensland. (Collector.—G. Masters).

Tabanus brisbanensis, *Taylor.*

Proc. Linn. Soc. N.S.Wales, xlii. (1917), p. 526.

Hab.—Queensland.

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A Malarial Survey of the Township of Cairns.[1]

BY

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It is well recognized that malarial fever has existed in Cairns in an endemic form for some years, but no definite information had been available as to the extent of its occurrence. A malarial survey of this township was undertaken to ascertain the prevalence and the source of the infection and to advise means for prevention.

It soon became apparent that conditions in Cairns differed, in a great many respects, from those prevailing in the majority of other malaria-infested regions. In most parts of the tropics where malaria has been endemic for generations, and where there exists a sedentary native population, the majority of the inhabitants become infected in early childhood, and acquire after years of suffering an active immunity, which is invariably preceeded by a state of tolerance, extending over many years. In endemic areas native children become infected soon after they are born; a number of them succumb to the infection; others suffer acutely at first, but soon they become accustomed to the presence of the parasites, and there exists for a time a state in which the organism and parasites are so well balanced that under normal conditions the parasites are unable to multiply, but at the same time the natural resisting power of the patient is just insufficient to eradicate completely the small number of parasites sheltering in the internal organs, such as spleen and bone marrow; there exists therefore a state of tolerance. Should, however, the balance be disturbed, should the general resistance of the organism be suddenly lowered, as for example by exposure to sudden cold weather, by extra exertion, or by intercurrent disease, the parasites may gain the ascendency; they are then able to multiply, and give rise to a new attack. Everybody who has travelled with natives, knows only too well that after a cold snap, and especially after prolonged exposure to cold rains, a number of apparently healthy natives are attacked by fever and ague.

Microscopical examination of the blood of children of a native village, where malaria is endemic, reveals, if performed carefully, a small number of parasites in a certain number of the blood specimens collected, mostly gametes or sexual forms. These parasites, when taken up with the blood by certain mosquitoes, which can act as carriers, multiply and allow the propagation of the infection to the non-immune population, newcomers and young children.

For this reason malaria is not considered a dangerous disease in a native community; the adults, born and reared in the endemic zone, hardly ever suffer, and the value of a child's life is, as a rule, not very highly estimated.

It is therefore only in the blood specimens collected from young native children living in an endemic area, that one can hope to encounter parasites; it is an event of rare occurrence to find parasites in the blood of an adult native.

In Cairns malaria has spread only within comparatively recent times, recent enough to prevent the formation of an immune adult population, and therefore one would expect *a priori* to find the young and adult population of this town equally affected.

Principles of a Malarial Survey.

A malarial survey must be carried out in two directions, since two factors are essential for the spread of the disease, on the one hand the patient harbouring the parasites in the blood, and on the other hand the parasite-carrying mosquito, the intermediary host. It is, therefore, necessary to ascertain in the first instance the number of inhabitants whose blood contains parasites in sufficient number to be detected on microscopic examination, and, secondly, to locate the breeding places of the malaria-carrying mosquito, by discovering the larvæ, pupæ, and eggs in collections of water.

Malaria-carrying mosquitoes belong in the light of our present knowledge to one genus only, namely to the Anopheles. The finding of the adult mosquito usually presents difficulties, as the anophelines are comparatively insignificant and shy mosquitoes, which rest in sheltered positions during the hours of daylight, especially on the under surface of leaves, in grass and on tree trunks. They leave their shelter, as a rule, just before sunset, and again just about sunrise, they develop for a short time their greatest activity, and become torpid again as soon as the daylight has vanished or the sun has risen. Anybody who has lived in tropical regions where anophelines are numerous, remembers only too well the activity of these mosquitoes just before sundown, when those parts of one's body, which are protected from light, such as ankles, calves of the legs and thighs, are the happy hunting ground of the blood-thirsty little beings, which fly away as soon as disturbed by any movement or by the direct rays of a lamp, but only wait in the near neighbourhood for a suitable opportunity again to attack their unfortunate prey.

It is generally understood that anophelines require especial conditions for their propagation, and their peculiar breeding habits afford an explanation for the frequent observation that during the early settlement of a recently opened up part of the tropics, malaria may be prevalent, and may become less and less marked as the township becomes more extended. Under especial conditions, however, such as are prevalent in Cairns, the opposite may take place when malaria, unless checked by preventitive measures, may spread with the extension of the township, on account of conditions favourable for the propagation of the mosquito.

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[1] This paper constitutes the beginning of a systematic survey of endemic malarial zones in Northern Australia.

Mosquitoes may be divided into two large categories, namely, town and bush dwellers. Town dwellers are those which are content to stay in houses and rooms, and lay their eggs in water tanks and other water-containing receptacles, so often found near habitations. An example is the *Stegomyia fasciata*, the transmitter of yellow fever, which clings to man and his progress. Bush dwellers visit buildings at their meal time only, and retire again after having taken their fill, to the bush, where they lay their eggs in natural water holes, and other collections of water, such as hoof marks in swamps, in old tree trunks, or in water collected between the branches and trunk of a tree, etc. The anophelines are typical bush dwellers, and hardly ever condescend to lay their eggs in artificial water containers.

Nyssorrhynchus annulipes which, judged by its distribution in relation to malarial infested regions in Northern Australia, most probably acts as malarial carrier, has another peculiarity. The ova and larvæ of this mosquito are never found in deep water, but only occur in shallow, still waters, such as are found on the edges of swamps, or in small pools on the surface of rocks, which are left when the water is drying up or receding. It is furthermore of importance to point out that *Nyssorrhynchus annulipes* does not refrain from propagating its species in brackish or even in salt water, although they prefer fresh water for oviposition. They lay their eggs also in muddy waters, and pupæ have often been encountered in muddy pools. Other species of anopheles have, however, different breeding habits. *Anopheles maculatus,* for example, which acts as malaria carrier in the hilly regions of Malaya, breeds in clear springs and crystal brooks, and the larvæ can, in spite of strong currents, hang on to rocks and pebbles in a stream, where not a blade of grass or other aquatic vegetation is to be found. (1)

Malarial fever is caused by the presence in the blood stream and organs of the sufferer of one of the species of the malarial parasite. At certain stages of the disease the parasite is present in the peripheral blood, and can readily be detected in fresh and stained blood smears on microscopical examination. The detection of the parasite in a blood specimen is, however, not always an easy matter, and the ease with which it can be accomplished, varies according to the type of the parasite, and the duration of the infection, and is made more difficult by erratic administration of small doses of quinine.

During the early stages of the simple tertian infection, caused by *Plasmodium vivax,* at the time of the second or even the third rigor, the number of parasites is, as a rule, so small that only a prolonged and a painstaking examination of several blood smears may reveal their presence; during the interval between the attacks, even a prolonged and lengthly search usually proves fruitless. As the infection progresses the number of parasites in the blood stream increases with each attack, and after a varying time certain forms, the sexual forms or gametes, persist in the blood, even during the feverless interval, so that in an untreated case after several attacks the finding of parasites does not, as a rule, offer much difficulty, even in blood specimens taken during the feverless interval.

In malignant tertian infection, due to *Plasmodium falciparum,* the asexual development takes place in the internal organs, such as spleen and bone marrow; the sexual forms, the crescents, persist in the peripheral blood in smaller or larger numbers according to the duration of the infection, and a microscopical diagnosis, even in a comparatively early stage is possible in blood specimens, taken irrespectively of the clinical manifestations. It is, however, a common experience that the number of crescents present in the blood stream is not in direct proportion to the severity of the clinical symptoms. In many instances, especially in the blood of the patients in a chronic stage of the disease, who have been treated with quinine intermittently, and in insufficient doses, the malarial cachexia produced by the infection may be well pronounced, but at the same time the number of parasites in the peripheral blood may be very small indeed.

This short discourse on the vicissitudes of the malarial parasite in general should reveal the fact that a careful but unsuccessful search for the parasites in a blood specimen taken at hazard is not at all conclusive of their absence, neither is an unsuccessful repeated examination performed at comparatively short intervals.

A well pronounced enlargement of the spleen in connexion with a history of fever is, however, even when parasites cannot be found in the blood, pathognomonic of malarial fever. The enlargement of the spleen is not always marked. A spasmodic and insufficient treatment by quinine, sufficient to prevent relapses for a few weeks, is apt to prevent an enlargement of the spleen, and in a community such as that of Cairns many patients are of this type.

Ross (2), in his discussion on the importance of enlargement of the spleen for estimating the amount of the disease in a locality, points out:—

> That even small and irregularly administered doses of quinine tend to check the increase of the spleen very much. Thus in untreated native children one often finds the organ an inch or so below the ribs after a few attacks, while there is frequently no enlargement in Europeans, even after many attacks. In sailors who have reached Liverpool after weeks or months of fever on the homeward journey from West Africa, we find, as a rule, scarcely any enlargement.

Of other symptoms, the presence of a mononuclear leucocytosis is considered an indication of latent malaria. Differential counts are, however, costly in time and only a well pronounced change in this direction is indicative of latent malaria.

Ross (2), the discoverer of the mosquito transmission of malaria, was the first to apply mathematical principles to malaria researches. He pointed out that malaria can only occur in a locality where the following conditions exist:—

(1) That a person whose blood contains a sufficient number of gametids (sexual forms) is living in or near the locality.
(2) That an anopheline capable of carrying the parasites sucks enough of that person's blood.
(3) That this anopheline lives for a week or more afterwards, under suitable conditions—long enough to allow the parasite to mature in it.
(4) That it next succeeds in biting another

person who is not immune against the disease or is not protected by quinine, and

(5) That few or no new infections will occur in a community, unless the persons with gametids in their blood and the carrying anophelines are sufficiently numerous.

He points out further that it requires a great number of malaria-carrying mosquitoes, and the number of infected persons must be fairly large, in order to allow malaria to spread, and adds that malaria cannot exist in a community unless the anophelines are so numerous that the number of new infections compensates for the number of recoveries. Ross's calculation proved that, provided precautionary measures are taken, it is not only possible but it is certain that malaria can be exterminated.

In order to advise ways and means for the eradication of malaria in Cairns, it was necessary to ascertain the breeding places of anophelines, and at the same time to ascertain the number of persons harbouring malarial parasites in their blood, who act as reservoirs for the further spread of the infection.

Mosquito Survey.

The township of Cairns is situated in the very low lying delta formed by the Cairns inlet, which extends for some distance inland with several ramifications, with extensive mangrove flats between the creeks. The country gradually ascends to a background formed by high hills which are densely covered by scrub, surrounding the town on three sides. Cairns, like other parts of North Queensland, has a dry and wet season; the rainfall is heavier during the wet season; the township is situated in the wet belt, and, as a rule, slight rains occur throughout the so-called dry season. The average rainfall for the last thirty years is 229.8 cm. (90.49 inches), in comparison with 125.2 cm. (49.28 inches) for Townsville.

The township of Cairns is built mainly on reclaimed land. The central part of the town is high and dry, and most of the main streets run parallel with the seashore and are intersected by cross streets. Most of the main streets, even within the confines of the town, run into swampy areas of varying extent, and further out towards the hills the town is completely surrounded by swamps, which hardly ever dry up completely and are covered by dense vegetation.

There are a number of main areas of swamps in and around Cairns.

The swamp situated between Abbott and Lake Streets is not of an extensive nature. The water is clear and fresh, varying from a few centimetres (a few inches) to about 60 centimetres (2 feet) in depth, the average being about 30 centimetres (12 inches). It is about 20 metres (66 feet) wide, wind swept in parts, and has a fairly dense growth of scrub; a few tall trees grow on its edges, as well as in the shallow water along the whole length of the swamp. In a few places there are houses facing Abbott Street, the back yards of which adjoin the edge of the swamp, and form in many instances part of it. Several large dead trees lies across the water as well as a quantity of fallen scrub; dead leaves cover the surface of the water along the edges as well as in the centre, where the tree trunks keep the flotage away from the bank.

There has been an attempt to fill in the swamp a short distance from its southern end, and a bridge of dry land divides it into two portions. The larger portion running in a nothern direction is a clear sheet of water; in the smaller, the southern portion, the surface is more or less covered by vegetation, consisting of water-lilies, reeds and other aquatic plants. The light scrub on the edges and the fallen trees in conjunction with the vegetation, cause an accumulation of flotage, so that the edges, well sheltered from the wind, furnish ideal breeding grounds, and contain a great number of mosquito larvæ.

Two anopheline mosquitoes were found breeding in the swamp, *Nyssorrhynchus annulipes* in abundance over its entire length, whilst larvæ of *Myzorhynchus bancrofti* were only rarely encountered.

This swamp continues beyond the houses to the town reserve, and forms a horse shoe shaped bend, which is separated from the seashore by a sand ridge. Occasionally, when the tides are exceptionally high, the sea breaks through this sand ridge, and the most northerly end of the swamp is then covered by salt water. Only a few larvæ of *Nyssorrhynchus annulipes* were in the pools; small numbers of fish, dragon-fly larvæ, and water-bugs were found in this swamp, which are commonly considered enemies of mosquito larvæ. Adult *Nyssorrhynchus annulipes* were found in the neighbourhood of the swamp.

The swamp between Sachs and Sheridan Streets commences immediately behind the General Hospital, and extends in a northerly direction parallel with the Lake Street swamp, and is about a chain wide. The first section is partially filled in by old tins and other rubbish, but is otherwise overgrown with water hyacinths. Further on it changes into moderately dense scrub, with an undergrowth of clumps of reeds, with banks on both sides up to two metres (six feet) in height. The water is fresh, and varies from a few centimetres to 100 of 120 cm. (3 or 4 feet) in depth. There is a fairly large quantity of flotage along the edges and round the clumps of reeds, mainly consisting of dead leaves. Towards its end it gradually merges into a salt water marsh, formed around a tidal creek; numerous pot-holes and small pools are found here in the soft mud along its banks. The undergrowth is gradually replaced by large trees in this area and finally gives place to thickly overgrown mangrove flats. The larvæ of the anophelines, *N. annulipes* and *M. bancrofti* were found in comparatively small numbers, *M. bancrofti* predominating.

Small fish were fairly numerous throughout the length of the swamp, whilst dragon-fly larvæ, water-boatmen, etc., were comparatively scarce.

Lily Creek consists of a series of swamps and water-holes, situated on the south-western side of the railway line, extending from one end of the township to the other, and beyond. Its beginning is a treeless swamp, overgrown with water hyacinths and with scattered pot-holes on the edges. In its middle portion it is covered with tall trees, and a fairly dense undergrowth. There is also a borrow pit in this portion between the swamp and the railway embankment completely overgrown with grass and containing about a foot of water. Towards its northerly end the swampy area extends in width considerably, and is densely timbered and covered with heavy undergrowth. The banks of the swamp are, generally speaking, low. The water is fresh and clear.

At about the same level as the Sach Street swamp this swamp continues into a brackish mangrove flat, formed by another branch of the salt-water creek referred to previously.

Larvæ of *N. annulipes* and *M. bancrofti* were not numerous in any portion of this swamp, but were fairly evenly distributed throughout. Larvæ of *M. bancrofti* predominated in the densely overgrown portion, whereas those of *N. annulipes* were more numerous in those parts adjoining habitations.

Culicine larvæ, pupæ, and egg rafts occurred throughout the entire length of the swamp, and were on the whole more prevalent than the anopheline larvæ. Small fish and dragon-fly larvæ were fairly well distributed throughout the swamp, the former being very common in the brackish areas toward the mangroves.

There are two separate swamps in the neighbourhood of Draper Street. The first swamp adjoins the south-western side of Draper Street, and is formed by a series of water-holes overgrown with water hyacinths and reeds. It becomes broader and its overflow is drained by means of a buried concrete pipe across the railway line into Alligator Creek. Closely adjoining, but separated by a low ridge there is a second more extensive swampy area, which extends across Draper Street. In parts it is heavily overgrown with water hyacinths and other vegetation, and in other parts forms an exposed sheet of water. There is a great number of houses in the near neighbourhood of these swamps.

Larvæ of *N. annulipes* and *M. bancrofti* in varying stages of development were found in small numbers in these swamps, but no adult mosquitoes were found in these areas.

The outskirts of the town are formed by undulating country, ridges running east and west, approximately parallel to the main streets, intersected by extensive swampy areas. The few houses are built on the sand ridges and are skirted by swamps of varying extent. The swamps are mostly heavily timbered by mangrove and gum trees, with a dense undergrowth of scrub. Here and there are partially cleared spaces covered by sheets of water. *N. annulipes* and *M. bancrofti* larvæ were found in varying numbers in most of the fresh water swamps, and in many instances water collected in the hoof marks of cattle and horses in the mud contained a varying number of larvæ. There are extensive tidal mangrove swamps running in from the seashore, watered by tidal creeks.

Malaria in the Community.

In order to ascertain as far as practicable the number of persons harbouring malarial parasites, blood specimens were collected from a number of residents. During the campaign 657 samples of blood were stained and subjected to microscopical examination,* out of these 88 contained malarial parasites in varying numbers.

There exist in Cairns two types of malarial parasites, *Plasmodium vivax,* the parasite of simple tertain fever, and *Plasmodium falciparum,* the parasite of the malignant tertain fever, so called on account of the greater severity of the clinical symptoms which this type of parasite produces.

Its gametocytes or sexual forms, the crescent forms, are not destroyed by the administration of even large doses of quinine, and only disappear after having completed their natural span of life, which comprises about twenty days.

Forty-five blood smears contained simple tertain parasites and forty-three smears the parasites of malignant tertain fever, which figures indicate that both types are fairly evenly distributed.

According to these results 13.5% of the inhabitants examined, harboured at the time of examination malarial parasites in their blood, and acted as distributing centres of the infection. In addition about twenty specimens, although not showing parasites, revealed blood conditions typical of a chronic malarial infection, namely, large mononuclear leucocytosis and degeneration of the red blood corpuscles, thus indicating that the persons, from whom the specimens were obtained had suffered, from fever within recent times. The parasites of quartan malarial fever were not encountered.

It is difficult to draw from this figure a definite conclusion as to the actual number of malarial cases which occur in the township of Cairns in the course of one year. A scanty number of parasites in the peripheral blood may easily be overlooked, and the percentage of positive results is in direct proportion to the time and care spent over the examination. Furthermore, in malarial fever attacks and feverless intervals follow each other in close succession, and the parasites, present in great number in the peripheral blood during the attack, lodge during the interval in the internal organs, and may be so scanty in the blood during the feverless intervals that they escape detection. It is only after a number of attacks uninfluenced by quinine, that a detectable number of gametocytes persist in the peripheral circulation, even during the afebrile stage.

On the other hand it must be taken into consideration that the collecting of blood samples was on the whole confined to parts of the town, where, according to the experience of the local practitioners, malarial fever had been prevalent, and only the blood of persons, who, on enquiry, professed to have had fever recently, or in whom a pronounced anæmia was present, was examined microscopically.

The admission rate of fever to the Hospital does not afford conclusive evidence as to the actual number of fresh infection occurring in the township. A certain percentage must be considered relapse cases, who leave the hospital too soon or do not continue the prolonged treatment necessary, and it is beyond doubt that only a small percentage of the patients—the most severe cases only—seek and obtain admission and treatment at the hospital.

Taking all circumstances into consideration, it is clear that the finding of parasites in 13.5% of the blood samples, represents a fairly high infection rate, and indicates beyond doubt that malarial fever is a widespread disease in Cairns and forms a serious handicap to the future development of the town.

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* The Senior Laboratory Assistant, Mr. J. W. Fielding, ably assisted in the examination of the blood smears.

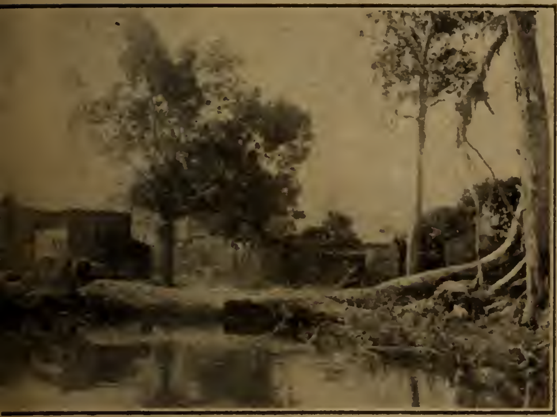


Figure I.
Swamp. Note the backyard of houses adjoining the swamp. Dead tree lying across swamp.

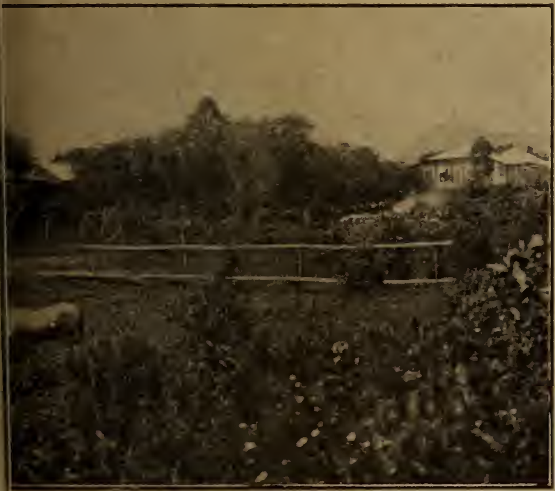


Figure II.
Swamp. The water is up to 60 cm. in depth. The surface with water hyacinths and clumps of reeds. Shallow pools e found everywhere, containing numerous anopheline larvæ.

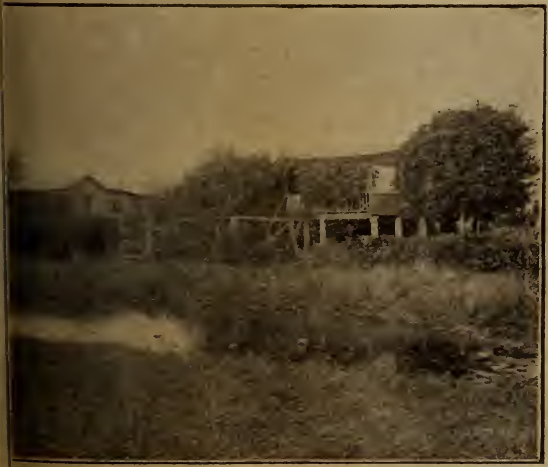


Figure III.
Swamp. Note the close proximity of the houses to the n, and the flotage on the edge, forming a favourable breeding ground for anophelines,

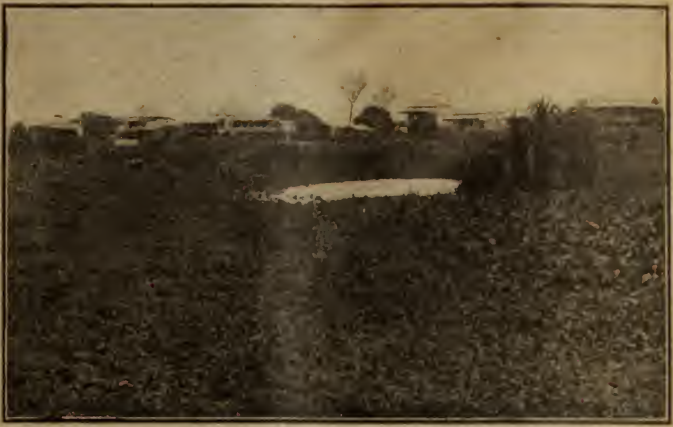


Figure IV.
Houses situated on edge of Draper Street Swamp.

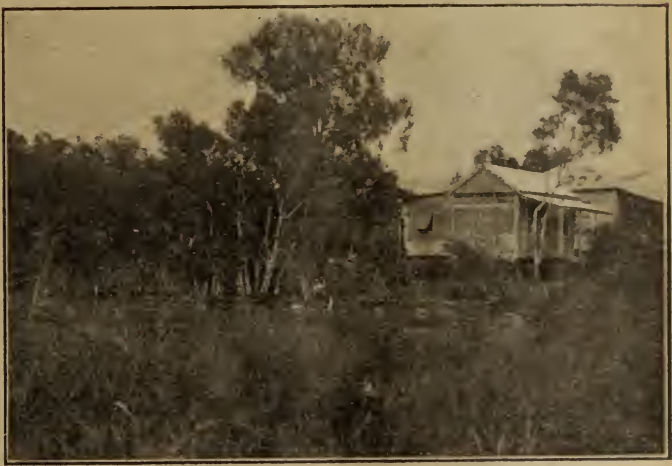


Figure V.
Corner of Mulgrave Road and Martyn Street. Note the pandanus trees on the edge of the water. Part of the swamp is overgrown with water hyacinths.

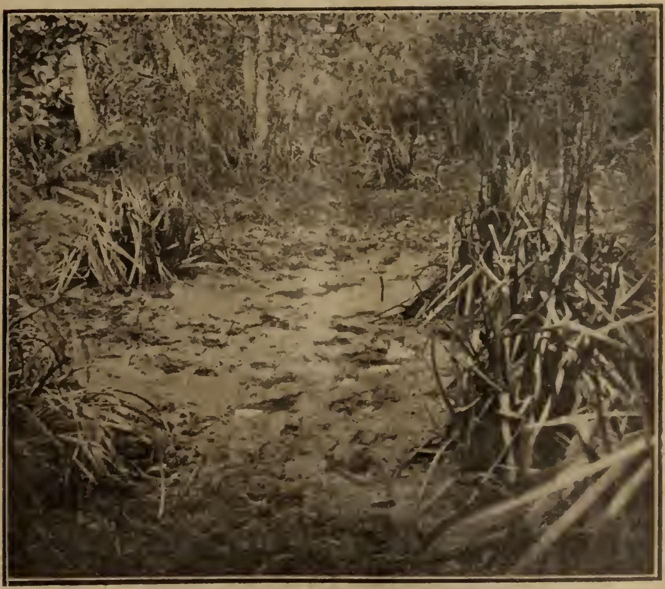
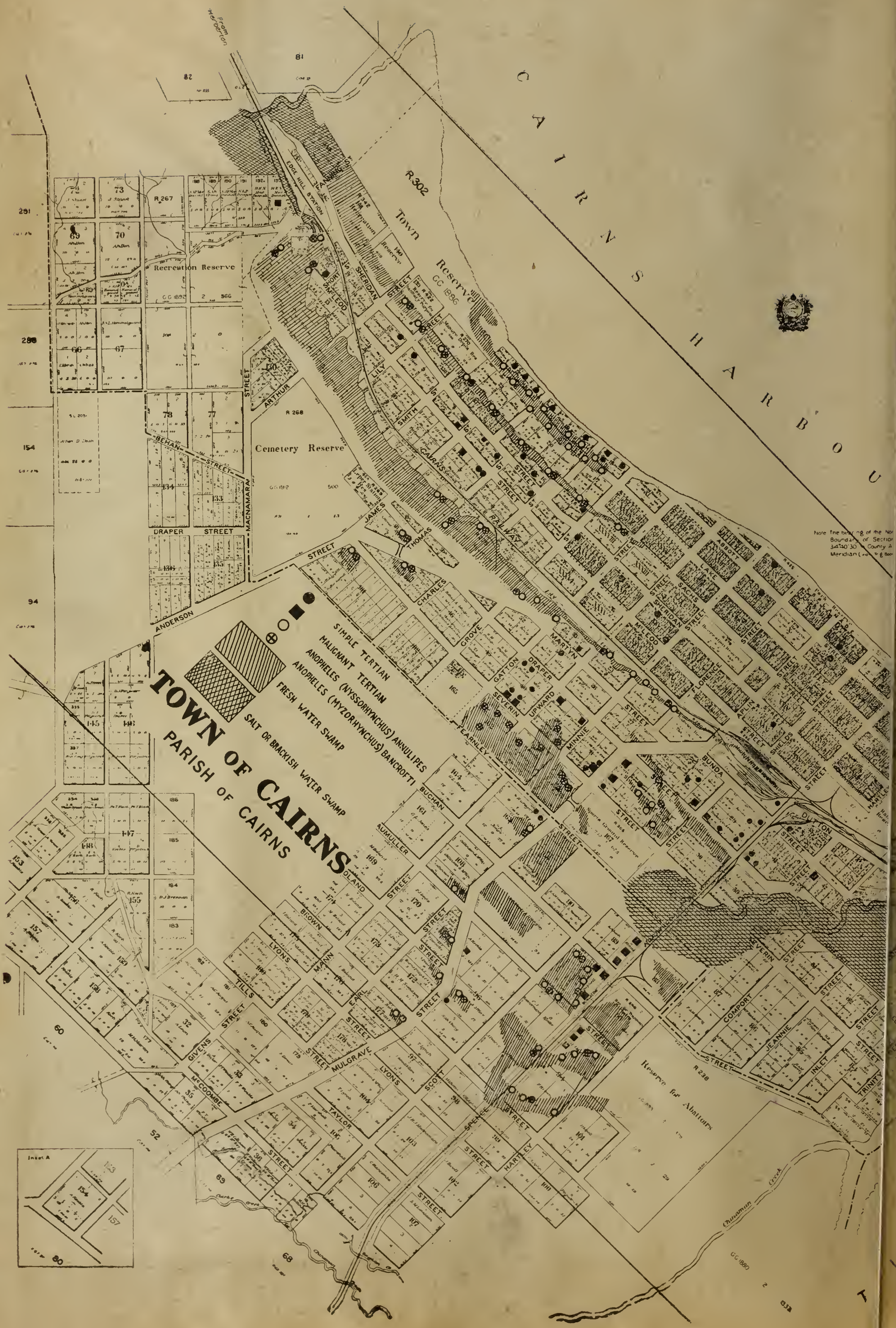


Figure VI.
Swamp alongside Mulgrave Road, on the outskirts of the town. Note the depressions in the mud, due to hoofmarks of cattle and horses, the water in which contained numerous anopheline larvæ.


TOWN OF CAIRNS
PARISH OF CAIRNS
SIMPLE TERTIAN
MALIGNANT TERTIAN
ANOPHELES (NYSSORHYNCHUS) ANNULIPES
ANOPHELES (MYZORHYNCHUS) BANCROFTI
FRESH WATER SWAMP
SALT OR BRACKISH WATER SWAMP
CAIRNS HARBOU
Town Reserve
Recreation Reserve
Cemetery Reserve
Reserve for Abattoirs
Inset A

he accompanying map shows the distribution of r cases throughout the town and the occurrence of heline larvæ. It is apparent at a glance that e exists a close relationship between the heline breeding swamps and the houses where l examination revealed the presence of fever cases.

Prevention of Malaria.

alaria is an infectious disease, which readily yields refully designed and rigorously carried out sani- measures, the cost of which is small in compari- with the havoc wrought by the disease.

e knowledge that the malarial parasite is carried the infected to the healthy by a certain species osquito only, and the proved fact that malaria ot be contracted by any other means than by the of an infected mosquito, indicate clearly that in larial campaign two enemies must be combated, y the malarial parasite in the blood of the patient, secondly the culpable mosquito. According to the conditions more attention must be paid to the one e other factor; but a durable peace can only be when both factors have been successfully ated.

rtunately quinine salts are a specific and nearly lible remedy, but only a prolonged and rigorous nistration of the drug can bring about a success- ure. The usual way of taking a few doses of ine for a short time, when the temperature is high the suffering acute, is more harmful than bene- . The attacks are cut short, a great number of sites are destroyed, but those which are more tant take shelter in the spleen and bone marrow, ing the bitter enemy, and appear again rejuven- in the blood after the last trace of quinine has eliminated.

e malarial parasites, which belong to the phylum rotozoa, possess a complicated structure, and with other protozoa the property of becoming tomed to a specific drug, when administered ically, and in small doses only, and even acquire a certain space of time a resistance against the . These quinine resistant parasites are after- s only influenced by a prolonged administration ssive doses of the drug.

order to form a conclusive opinion as to the ncy of the treatment, a conscientiously carried ystem of notification is essential under the super- of a health officer, alive to his responsibilities. The notification of a number of new cases from a certain area would prove the existence of a parasite carrier, spreading the infection broadcast, and an enquiry would locate the carrier, and would make it possible to remove the evil influence by freeing his blood from parasites.

The eradication of the mosquito is of equal importance for the success of an antimalarial campaign. This can be accomplished by destroying the larvæ and pupæ, and preventing as far as possible the adult female mosquitoes from laying their eggs, by removing all collections of water suitable for breeding, existing within the precincts of the township. The range of flight of mosquitoes is somewhat limited, and mosquitoes do not travel more than half a mile, unless driven by a strong wind.

The dealing with swamps is purely an engineering problem. Swamps may be either filled in or, wherever possible, be drained. Should, however, on account of the extent of the water collection, or for other reasons, draining be impossible, a systematic oiling of the surface may minimize the mosquito plague.

The efficiency of a systematic application of a larvacide has been demonstrated by the Americans in Panama (3), where a phenol-resin soap was used for this purpose, which in a 1 in 5,000 emulsion killed full-grown anopheles larvæ in from ten to twenty minutes, and possessed a low toxicity to higher animals, being practically harmless to cattle, poultry and other domestic animals in ordinary doses or in dilutions used. The success of the oiling of swamps, however, depends entirely on the care with which the operation is carried out, and careless and spasmodic oiling is perfectly useless.

A thoroughly carried out malarial campaign represents a sound investment on the part of the affected community. The economic loss, caused by the inefficiency of labour on account of malarial infection, by hospital expenditure, and by the evil reputation of the health of the town, justifies, as a rule, even a large capital expenditure.

Literature.

(1) Malcolm Watson—"Rural Sanitation in the Tropics," London, John Murray, 1915.

(2) Ross—"The Prevention of Malaria," London, John Murray, 1910.

(3) Le Prince and Orenstein—"Mosquito Control in Panama," Putnam & Sons, New York, 1916.

Shipping Newspapers, Limited, 16 Bond Street, Sydney.

UDIES IN PHLEBOTOMIC DIPTERA, No. 1. NEW SPECIES OF SIMULIDÆ AND CHIRONOMIDÆ.

FRANK H. TAYLOR, F.E.S. (from the Australian Institute of Tropical Medicine, Townsville.)

(Figs. 1—3.)

d-flies have, in the case of the Simulidæ, been greatly neglected in Australia. There have scribed, so far, only two species, *S. furiosum*, Skuse, and *S. victoriæ*, Rouband.

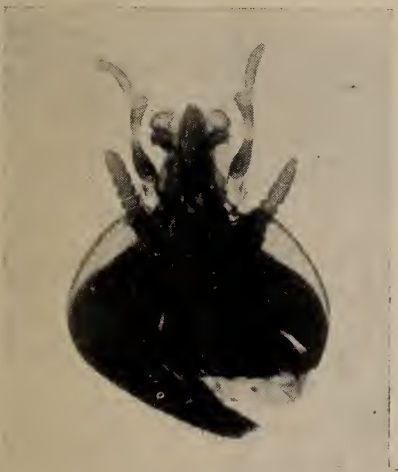
n now enabled to add another species, thanks to the courtesy of Dr. T. L. Bancroft, who kindly d a series of dried specimens and also some preserved in alcohol to the Institute.

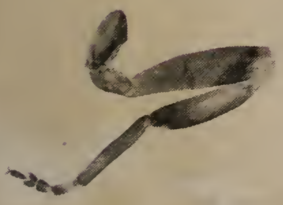
Chironomidæ are somewhat better represented, as seventy-six species, distributed in seventeen have been described to date, mainly by Skuse in 1889.

o new species are described in this paper—one of which was taken by Dr. J. H. L. Cumpston, of Quarantine, and kindly presented to the Institute by him. The other was taken by my e, Dr. W. J. Young.

type specimens are contained in the Institute collection.

Fig. 1





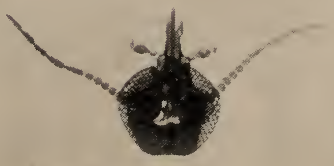


Fig. 2

Fig. 3

Family SIMULIDÆ.

SIMULIUM BANCROFTI, *sp. n.*

(Figs. 1 and 2.)

Head black with grey tomentum ; front with a well-defined median groove ; palpi blac black and pale pubescence, first joint pale, apex of second narrower than base, third strongly emar on the inner side towards the apex, fourth long, thin, cylindrical ; antennæ nine-jointed, firs brownish, first shorter than second, latter about the length of the third, third to the apex black, broadest and about twice the length of fourth ; proboscis black, apex with short, stout pubesc eyes coppery.

Thorax : Black, tomentum grey, pubescence pale ; pleuræ black with grey tomentum.

Abdomen : First segment deep black, two to six deep black with median apical ash-grey small on the second and increasing in size to the sixth, which is ash-coloured, except for a n basal and lateral margin of deep black, seventh ash-grey, with a narrow lateral deep black b eighth ash coloured, third to fifth also with apices of sides ash-coloured, pubescence black, p the pale areas ; venter grey with grey pubescence. Halteres pale creamy.

Legs : Dark yellowish-brown, tibiæ dark brown above, anterior tarsi black, except base yellowish-brown, mid and posterior tarsi yellowish-brown, second to fourth with their apices first posterior tarsi dusky beneath ; pubescence pale ; apex of tibiæ with a stout spine ; apex posterior tarsi produced into a terminal expansion overlapping the second tarsals beneath.

Wings : Clear, pale yellowish at the roots ; costa auxiliary and first long veins paler than remaining veins almost indistinguishable from wing membrane.

Length, 2 mm. ; length of wing, 2 mm.

Hab.—Q. : Eidsvold (Dr. T. L. Bancroft).

The wings, legs and abdominal ornamentations render this species abundantly distinc *S. furiosum*, Skuse, and *S. victoriæ*, Rouband. It resembles *S. jolyi*, Rouband, from New He in having an apical terminal expansion on the first posterior tarsi.

It affords me much pleasure to dedicate this species to its discoverer.

SIMULIUM FURIOSUM, *Skuse.*

Proc. Linn. Soc. N.S. Wales, xiii., p. 1365, 1888 (1889), pl. xxx., fig. 1.

A specimen, on a card, presented to the Institute by Dr. Ferguson, may possibly be this but it is in a very poor state of preservation and is more or less covered with gum, which has o details, thus rendering its determination indefinite.

Hab.—N.S.W. : Narromine (Dr. Ferguson).

Family CHIRONOMIDÆ.

CULICOIDES TOWNSVILLENSIS, *sp. n.*

(Fig. 3.)

Head : Black, with golden pubescence ; antennæ blackish-brown, apex of last joint nipple [illegible], ce dark ; palpi dark brown, pubescence pale, first two segments longer than third and fourth second segment strongly emarginate on its inner edges, first segment with a distinct notch ter edge of the basal third ; eyes black.

rax : Dull black, with fairly dense lemon coloured pubescence, scutellum similar ; pleuræ Halteres with orange coloured knobs.

omen : Black, with dark brown pubescence ; venter brown.

: Femora brown, tibiæ and tarsi yellowish-brown, pubescence pale, fairly long on the femora, e about two and a half times the length of first tarsi, posterior tibiæ about twice the length arsi.

gs : Longer than abdomen, clear, covered with brown pubescence ; costa, first and second nal veins brown, the latter reaching the costa considerably in front of the base of the fifth nal fork.

th, 1 mm. (vix) ; length of wing, 1 mm.

—Q. : Townsville (Dr. W. J. Young).

ribed from five specimens taken during the morning while biting. It appears to be most elated to *C. minusculus* (Skuse), but is readily distinguished on venational characters

CULICOIDES MULTIMACULATUS, *sp. n.*

lead : Black, pubescence pale ; antennæ with scape, black, prominent, pedical yellowish, an following joint and about twice as wide, next seven joints pale yellowish-brown, remainder e apical longest, stout, and ending in a blunt point ; proboscis and palpi dark-brown, the e second joint swollen, pubescence black.

Black, with brown tomentum, sides with grey tomentum not reaching the shoulders, t superimposed in front of the wing roots and two large grey ones in the centre of the nce pale ; scutellum black.

men : Black, with faint grey tomentum, pubescence pale, scanty.

: Brown, femora and tibiæ with a subapical pale ring, pubescence black ; fore tibiæ about a half the length of the first tarsals.

Brown, longer than thorax and abdomen, with [illegible] clear spots, the largest situated e apex of the first long vein ; veins brown ; first and second long veins reaching the costa bly in front of the base of the fifth longitudinal fork ; pubescence black, fairly dense.

Length, 1.5 mm. (vix); length of wing, 1.75 mm.

Hab.—Victoria: Portsea (Dr. J. H. L. Cumpston).

This species is more nearly related to *C. marmoratus* (Skuse) than to *C. molestus* (Skuse), the two known southern forms with spotted wings. It may, however, be distinguished by the spots more numerous and irregular in size while they appear to be more regular in size in *C. marmoratu* *C. molestus*. It also differs in thoracic ornamentation.

EXPLANATION OF FIGURES.

Fig. 1.—*Simulium bancrofti*, sp. n., head.

Fig. 2.—*Simulium bancrofti*, sp. n., posterior leg.

Fig. 3.—*Culicoides townsvillensis*, sp. n.

[*From the Proceedings of the Linnean Society of New South Wales,*
1918, Vol. xliii., Part 4, November 27th.]

CONTRIBUTIONS TO A KNOWLEDGE OF AUSTRALIAN *CULICIDÆ*. No. iv.*

By Frank H. Taylor, F.E.S.

(From the Australian Institute of Tropical Medicine, Townsville).

(Plates lxxx.-lxxxiii.)

This paper may be divided into two parts, synonymical and descriptive, with notes on previously described species.

Two species described by me from the Northern Territory belong to species recorded from extra-Australian localities; their distribution is noted in the text. The Australian *Anopheles* are also tabulated. It will be seen that very few of the Anopheline genera are recognised, and those only as subgenera, except in the case of *Bironella.*

The new species are distributed in the following genera :—*Pseudoskusea* (one), *Mimeteomyia* (two), *Culicada* (one), *Lophoceratomyia* (one), *Uranotænia* (four), and *Hodgesia* (one).

The type-specimens are contained in the Institute Collection.

The following tabulation of the Australian *Anopheles* is given in the hope that it may prove useful in the determination of the species in question.

Anopheles corethroides, *A. stigmaticus*, and *B. gracilis* have been tabulated from descriptions only, as the Institute does not possess specimens of them. *A. punctulatus* Dönitz, is omitted from the Table, as it is unknown to me either from specimens or description.

It will be seen that all the species, except *B. gracilis*, are placed in the genus *Anopheles.* This is best explained by referring the reader to a paper by A. Alcock,[†] which deals with the "Classification of the Culicidæ," and with which the writer

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[*] Continued from these Proceedings, 1916, p.574.

[†] Ann. Mag. Nat. Hist., (8), viii., p.240 (1911).

entirely agrees, as the genera cannot, in some cases, be regarded even as subgenera; while, in others, they form convenient subgeneric or group-names.

Alcock* retains the following as subgenera: *Anophiles* (s.r.), *Myzorhynchus*, *Myzomyia*, and *Nyssorhynchus*. I would add to these the genus *Bironella*, as valid on venational characters—if it really be an *Anopheline*. Theobald, himself, throws doubt on its systematic position.

ANOPHELES.

A. Wings spotted.
  i. Legs unbanded.
    a. Wings with the third, fourth, fifth, and sixth long veins brown- and white-scaled. No costal spots .... *atratipes* Skuse.
    b. Wings with one fringe-spot......... . ... *barbirostris* V. d. Wulp.
    bb. Wings with several fringe-spots...*barbirostris* var. *bancrofti* Giles.
  ii. Legs banded.
    a. Wings with numerous light and dark spots.
      Costa with six spots.
      Femora and tibiæ with numerous pale bands, tarsals 1-4 with apical and basal banding .... *annulipes* Walker.
B. Wings unspotted.
  i. Legs unbanded.
    a. Thorax with long, curved, hair-like scales... *corethroides* Theobald.
    aa. Thorax with three rows of golden-yellow, narrow-curved scales ... . *stigmaticus* Skuse.

BIRONELLA.

A. Wings unspotted, third long vein, stem of second fork-cell, and fifth long vein curved.
  i. Legs unbanded.
    a. First fork-cell very small .... *gracilis* Theobald.

ANOPHELES (MYZORHYNCHUS) BARBIROSTRIS Van d. Wulp, var. BANCROFTI (Giles).

(Plate lxxx., fig.1).

Theobald, Mon. Culicid., v., p.50 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1915, xl., p.176.

This is a common and widely distributed species, extending from Darwin, N. Territory, to Eidsvold, S. Queensland.

The male is evidently very retiring, as the only known specimens have been bred from larvæ.

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* Journ. Lond. Sch. Trop. Med., ii., p.153 (1913).

ANOPHELES (NYSSORHYNCHUS) ANNULIPES Walker.

Ins. Saund., p.433 (1850); Theobald, Mon. Culicid., v., p.57 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.454; Quarantine Service Publication, Melbourne, No.12, 1917.

Hab.—N.S.W.: Hay (W. W. Froggatt).—Victoria: Melbourne (Dr. J. H. L. Cumpston); Kyabram, Bamawm, Echuca, Swan Hill, Mildura, Cohuna, Lake Boga (F. H. Taylor).—S. Australia: Renmark, Cobdogla, Pompoota (F. H. Taylor).—W.A.: Perth, Kalgoorlie (Dr. Atkinson).

This mosquito is probably the most widely distributed species in Australasia, as it extends from Darwin, in the North, across to Papua, throughout the mainland, and southward to Tasmania. It is not improbable that this species will be found in the Pacific Islands.

TOXORHYNCHITES INORNATUS (Walker).

Proc. Linn. Soc. Lond., viii., p.102 (1865); Theobald, Mon. Culicid., i., p.223 (1901); *op. cit.*, v., p.110 (1910).

Two male specimens, one of which is quite typical; the other has the mid cross-vein confluent with the posterior cross-vein instead of not meeting it, and also has the second tarsals of the hindlegs with a broad, white, almost basal band, which occupies more than half the joint. It agrees in all other points with Theobald's description of this species.

Hab.—Papua: Itikinumu Plantation (F. P. Dodd).

TOXORHYNCHITES SPECIOSUS (Skuse). (Plate lxxx., fig.2).

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1722 (1889); Theobald, Mon. Culicid., v., p.108 (1910).

Hab.—Q.: Townsville (Dr. A. Breinl).

MUCIDUS ALTERNANS (Westwood).

Ann. Soc. Ent. Fr., iv., p.681; Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.455; *op. cit.*, 1915, xl., p.176.

Hab.—Victoria: Kyabram (F. H. Taylor).

This species is known to range from Darwin to Victoria.

ARMIGERES BREINLI Taylor; *Neosquamomyia breinli* Taylor.
(Plate lxxx., fig.3).

Trans. Ent. Soc., London, 1914, Pt. i., p.186.

The genus *Neosquamomyia* was founded partly on the male genitalia, the other characters agreeing with *Armigeres*.

When proposing the genus, I was unaware that similar characters were to be found in species of the genus *Armigeres*, notably *A. malayi* Leicester.

Edwards* notes the similarity of *A. malayi* Leic., and *N. breinli* Taylor, and suggests that the correct position for the latter species is in *Armigeres*, a decision with which I quite agree. The two species are distinct, but certainly closely related.

PSEUDOSKUSEA CAIRNSENSIS, sp.n.

♀. Head clothed with black, flat, and upright-forked scales; palpi dusky; antennæ dark brown; proboscis black.

Thorax dark reddish-brown with brown scales, scutellum similar; pleuræ brown, with white, flat scales.

Abdomen black-scaled, unbanded, segments three to the apex with basal, lateral, white patches; venter pale-scaled.

Legs black, unbanded; ungues equal and simple.

Wings brown-scaled; first fork-cell longer and narrower than the second, its base nearer the base of the wing; stem of first fork-cell one-third the length of its cell, stem of second fork-cell slightly more than half the length of its cell; anterior basal cross-vein longer than, and twice its own length distant from, the anterior cross-vein. Length, ?

Hab.—Queensland: Cairns (F. H. Taylor).

Described from a single specimen bred from a mixed lot of larvæ. It is readily distinguished from *P. multiplex* Theobald, on venational characters, ungues, and the abdominal spots. It differs from *P. basalis* Taylor, in not having a banded abdomen.

MIMETEOMYIA ATRIPES (Skuse).

Stegomyia punctolateralis Theobald.

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1750 (1889); Theobald, Mon. Culicid, iv., p.190 (1907); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxviii., p.750 (1915) (*Scutomyia*); *op. cit.*, 1915, xl., p.177 (*Stegomyia*).

It is quite evident, from specimens recently collected by myself,

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* Bull. Ent. Res., vii., p.207 (1917).

that Skuse's species has the apical lateral spots on all the abdominal segments, and *not* only on the sixth to eighth segments, as stated in my paper (1914). The Ingleburn specimens show that the spots vary somewhat in size on the basal segments, so that they were either overlooked in the type, or the abdomen was partially abraded.

There is also no doubt at all that *Stegomyia punctolateralis* Theobald, is the same as *M. atripes* (Skuse). *S. punctolateralis* Theob., was unknown to me, except from description, when I stated (1914) that the two were different species; but, since then, Dr. Bancroft has presented a series of both sexes to the Institute, which clearly show they are the same as Skuse's species.

Theobald states that the mid-ungues of the male are unequal and simple; this is an error, as the larger is uniserrate.

Neveu-Lemaire* places *M. atripes* in *Theobaldia*, and records it from Guyane. He states that the fore- and mid-ungues of the female are uniserrate; and he gives a figure of the wing-scales of his specimens, which proves conclusively that he was not dealing with Skuse's species. He also states that the palpi are four-jointed.

There is no doubt that it belongs to the genus *Mimeteomyia*, as, *inter alia*, the apex of the abdomen is very bristly.

Hab.—Q.: Eidsvold (Dr. Bancroft), Burketown, Townsville (F. H. Taylor).—N.S.W.: Milson Island (Dr. Ferguson), Blackheath (W. A. Thompson), Ingleburn (F. H. Taylor).—Vic.: Mildura (F. H. Taylor).

MIMETEOMYIA ATRA (Taylor).

Stegomyia atra Taylor, Trans. Ent. Soc. London, 1914, p.190.

A re-examination of the type of this species reveals the fact that it should, more correctly, be placed in the genus *Mimeteomyia*, on account of its bristly and truncated apex of the abdomen, among other points of agreement with the genus.

MIMETEOMYIA PULCHERRIMA, sp.n.

♂. Head covered with brown, flat scales, with a median row of white ones, and white ones laterally; antennæ pale, nodes and

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* Arch. Parasitologie, vi., p.615 (1915).

plumes brown, basal lobes with white, flat scales; eyes wine-red; palpi brown-scaled, first segment with two prominent white bands, penultimate and apical segments with white, basal bands.

Thorax with dark brown scales, and ornamented with a lyre-shaped pattern of small, white, flat scales; prothoracic lobes with white scales and black bristles; scutellum with white, flat scales; pleuræ brown, with patches of white, flat scales.

Abdomen brown-scaled, expanded apically, segments one to six with small, median, white, basal patches; all segments, except the first, with white, lateral, basal patches, prominent in the last three segments; genitalia with numerous black bristles; venter brown-scaled, with median, white, basal patches on the first seven segments.

Legs brown, knees white, first and second fore- and mid-tarsals with basal, white banding, posterior tarsi one to three with broad, white, basal bands, fourth white, with a narrow, brown, apical band, fifth white; ungues of fore- and mid-legs unequal, the larger with a distinct notch, hind equal and simple.

Wings : bases of fork-cells equal, first longer and narrower than second, stem of first fork-cell not quite half the length of its cell, stem of second slightly more than half the length of its cell, anterior basal cross-vein longer than, and twice its own length from, the anterior cross-vein; vein-scales brown.

Length, 3 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from a single specimen, bred from a collection of larvæ. It is abundantly distinct from all other Australian species of *Mimeteomyia*.

MIMETEOMYIA DODDI, sp.n.

♂. Head covered with black scales, a median row of white, flat ones, and white, flat ones laterally; antennæ brown, plumes brown, internodes pale; palpi brown, penultimate segment basally banded white, apical segment white-scaled; eyes silvery.

Thorax covered with dusky-brown scales; scutellum with brown scales; pleuræ brown, with patches of white, flat scales.

Abdomen covered with coppery-brown scales, first segment brown-scaled, second with a median, basal, white-scaled spot, third to fifth and apical segments with white, basal banding, all segments with white, lateral, basal spots; venter brown, with white basal banding and numerous pale hairs.

Legs dusky-brown, first tarsals of forelegs basally banded white, the rest unbanded, first tarsals of mid-legs basally banded white [the rest broken off], posterior tarsi one to three basally banded white, fourth unbanded, fifth white; ungues of forelegs unequal, the larger with a tooth, hind equal and simple,

Wings: first fork-cell longer and narrower than the second, its base nearer to the base of the wing; stem of first fork-cell one-third the length of its cell, stem of second slightly more than half the length of its cell, anterior basal cross-vein longer and twice its own length from the anterior cross-vein.

♀. Similar to ♂. Antennæ brown, basal half of first joint yellow; apical third of palpi white. Abdomen: fourth and fifth segments with basal, white banding, apex of abdomen white-scaled, and with numerous pale bristles, all the segments, except the first, with lateral, white, basal spots; second segment with a white, median, basal spot; venter pale-scaled, apical segments black-scaled.

Legs similar to those of ♂, second tarsals of mid-legs with white basal banding; ungues equal and simple. Wings as in ♂.

Length: ♂, 2·5; ♀, 3·5 mm.

Hab.—Papua: Itikinumu Plantation (F. P. Dodd).

A very distinct species, readily distinguished from *M. pulcherrima* mihi, by its palpi, thoracic and abdominal markings. There is little doubt that the female belongs to the same species.

It affords me much pleasure to name it in honour of its discoverer.

GRABHAMIA THEOBALDI Taylor. (Plate lxxxi., fig.4).

Theobald, Mon. Culicid., iv., p.304 (1907). *C. flavifrons* Theob., *nec* Skuse, Proc. Linn. Soc. N. S. Wales, 1913, xxxviii., p.751 (1914).

Were it not for intergrading forms, it would be possible to make two distinct "species" out of the series of specimens before me, on abdominal markings alone, as, in some specimens, the abdomen is quite typical, whilst, in others, it varies from specimens with distinct basal banding on the first two segments of the abdomen, and the remainder with more or less indefinitely banded and mottled, to those with indefinite basal banding and dense mottling of creamy scales on all the abdominal segments.

The base of the second fork-cell is slightly nearer the base of the wing than that of the first, while they are nearly level in the type.

Specimens from Eidsvold, Queensland, show similar intergradient forms to the above Victorian specimens.

Hab.—Vic.: Bamawm, Kyabram, Mildura, and Echuca (F. H. Taylor).

CULICADA WILSONI, n.sp. (Plate lxxxi., figs.5, 6, 7).

♂. Head black, covered with yellowish, narrow-curved and upright-forked scales, with a few yellowish hairs projecting over the eyes, sides of head with flat ones; palpi longer than proboscis, black, first joint pale-scaled, except the apical fourth, pubescence black on the apical segment, and apex of first, yellowish-brown on the penultimate segment; antennæ pale, nodes dark, plumes brownish-black, dense.

Thorax black, covered with yellowish, narrow-curved scales; prothoracic lobes with flat ones; scutellum similar; pleuræ black, with flat scales.

Abdomen black, first segment pale-scaled, second to seventh with broad, yellowish, basal banding; sixth, seventh, and eighth mottled; some specimens show median pale-scaled bands on most of the segments; genitalia with some long, black hairs, lateral pubescence dense, yellowish; venter pale.

Legs black, femora pale beneath; femora, tibiæ, and tarsi mottled; fore-ungues unequal, uniserrate, mid unequal, the larger deeply notched, the smaller uniserrate, hind equal and simple.

Wings with brown scales; first fork-cell longer and narrower than the second, base of latter nearer the base of the wing, stem of the first almost as long as its cell, stem of second as long as the cell; anterior basal cross-vein about as long as, and nearly its length from, the anterior cross-vein; second incrassation well marked.

♀. Similar to ♂; antennæ black, basal lobes black, with creamy-yellow scales, basal half of second joint pale, verticillate hairs black, pubescence pale; palpi four-jointed, black-scaled, with intermixed, scattered, pale scales; proboscis black; fore femora pale-scaled, mid and hind pale, with an apical black ring, tibiæ and first tarsals mottled with pale scales; fore- and mid-ungues equal, uniserrate; penultimate abdominal segment creamy-scaled except for a small oblique apical line of dark scales, apical creamy-scaled. Wings similar to those of the male; but fork-cells relatively longer, stem of first fork-cell two-thirds the length of its cell, that of second about three-fifths of the cell.

Length: ♂, 7·5; ♀, 6 mm.

Hab.—Vic.: Kyabram, Echuca, Bamawm, Swan Hill, and Mildura (F. H. Taylor).

This appears to be a well-defined species related to *C. tasmaniensis* Strickland, differing, *inter alia*, in the wing-venation, and the mottled femora, tibiæ, and first tarsals. *C. wilsoni* was present in enormous numbers in the Goulburn Valley district, Kyabram and Bamawm being inundated with them. There is a small area of cypress-pine (*Callitris* sp.) at Bamawm, and it was impossible for man or beast to remain in it for even a few minutes, owing to the abundance of this mosquito.

I have much pleasure in dedicating this species to Mr. Wilson, of Bamawm, who rendered me much help and kindly service while I was in that district.

OCHLEROTATUS NOTOSCRIPTUS (Skuse).

Proc. Linn. Soc. N. S. Wales, 1888, xiii., p.1738 (1889) [*Culex*]; Theobald, Mon. Culicid., v., p.200 (1910) [*Scutomyia*]; Edwards, Ann. Mag. Nat. Hist., (8), ix., p.523 (1912).

Hab. N.S.W.: Ingleburn.—Vic.: Swan Hill (F. H. Taylor).

CULEX SITIENS Wiedemann.

Aussereurop. zweiflüg. Ins., p.544 (1828); Theobald, Mon. Culicid., v., p.331 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1916, xli., p.570.

Hab —Q.: Cairns, Innisfail (F. H. Taylor).—Papua (F. P. Dodd).

This common mosquito enjoys a wide distribution, being found from Java through Papua and Torres Straits to Victoria.

CULEX CONCOLOR Desvoidy.

Mém. Soc. d'Hist. Nat. Paris, iv., p.405 (1825); Edwards, Bull. Ent. Res., ii., p.262 (1911).

Hab.—Q.: Innisfail (F. H. Taylor).

A short series, bred from larvæ, have been compared with specimens from other Australian localities, and also with specimens of *C. concolor*, *C. tigripes*, *C. consimilis*, and the form described as *C. tigripes* var. *fusca*, which have been received from the Imperial Bureau of Entomology; and there is absolutely no doubt, as Edwards states, that the Australian form belongs to *C. concolor*.

All references dealing with *C. tigripes*, as from Australia, should, therefore, refer to *C. concolor*, and *C. tigripes* should be expunged from the Australian list.

CULEX BITÆNIORHYNCHUS Giles.

Journ. Bombay Nat. Hist. Soc., xiii., p.607 (1901); Edwards, Bull. Ent. Res., iv., p.231 (1913). *C. abdominalis* Taylor, Rep. Aust. Inst. Trop. Med., 1911, p.53 (1913).

Edwards gives several synonyms of *C. bitæniorhynchus* Giles, in his paper, and mentions *Culicelsa abdominalis* Taylor, also as a possible synonym.

I have compared specimens of my species with six specimens of *C. bitæniorhynchus* Giles, from Hong Kong, and can see no valid reason for treating them as a distinct species, thus confirming the opinion held by Edwards.

CULEX VISHNUI Theobald.

Mon. Culicid., i., p.355 (1901) (♀ only); Edwards, Bull. Ent. Res., iv., p.233 (1913). *C. parvus* Taylor, Bull. N. Territory, 1*a*, p.27 (1912).

Edwards included *C. parvus* Taylor, as a probable synonym of *C. vishnui*, when dealing with its synonymy in his paper. I quite agree with this, and place *C. parvus* definitely as a synonym of *C. vishnui* Theobald.

It seems to me that *C. vishnui* Theobald, is closely related to *C. sitiens* Wied.

CULEX TOWNSVILLENSIS, nom.nov.

Culicelsa fusca Taylor.

Trans. Ent. Soc. London, 1914, p.699.

A change of name is necessary, as *fuscus* is preoccupied in Culex.

The sixth and seventh segments of the abdomen have the sides covered with white scales, except the apex; eighth pale-scaled, unbanded. The fore- and mid-ungues are unequal, and *not* equal, as stated in the description, the mid more so than the fore. There is also a small branched process on the undersurface at the base of the ungues in both legs. Genitalia of male of typical Culex-form.

♀. Similar to ♂. Palpi brown-scaled; apex of abdomen hairy. First fork-cell longer and narrower than second, its base nearer the base of the wing than that of the latter, stem of the first about one-third the length of the cell, stem of the second slightly more than half the length of the cell; hind-tibiæ the same length as first tarsals; ungues equal and simple.

Hab.—Q.: Townsville (F. H. Taylor).

The above corrections in the description of the male are based on fresh material, which agrees perfectly with the type. It appears to be an uncommon species.

CULEX FATIGANS Wied.

Aussereurop. zweiflug. Ins., p.10 (1828); Taylor, Trans. Ent. Soc. London, 1914, p.197.

Hab.—N.S.W.: Sydney (F. H. Taylor).—Vic.: Melbourne (Dr. Cumpston), Kyabram, Echuca, Mildura, Bamawm, Swan Hill (F. H. Taylor).—S. Australia: Renmark, Cobdogla, Overland Corner, Pompoota, Adelaide (F. H. Taylor).

C. fatigans is a common mosquito in Southern Australia. It occurred abundantly at Kyabram and Echuca, where it was breeding in enormous numbers in the irrigation-channels and street-watertables.

LOPHOCERATOMYIA CAIRNSENSIS, sp.n. (Plate lxxxii., figs.8, 9).

♂. Head clothed with brown, narrow-curved, and black, upright-forked scales; antennæ pale, apical segments and nodes dark brown, plumes brown, accessory organs long on segments five, eight, and ten, apices spoon-shaped on eighth, short on sixth and seventh; palpi black, penultimate and apical segments with black hairs beneath, thumb-like process dark brown; eyes black.

Thorax and scutellum with brown, narrow-curved scales; scutellar bristles black, long; pleuræ brownish.

Abdomen black-scaled, unbanded, apex bristly, segments three to seven with faint, lateral, basal spots; venter dark.

Wings: first fork-cell longer and narrower than the second, the former nearer the base of the wing; stem of first fork-cell about half the length of its cell, stem of second about two-thirds; anterior basal cross-vein longer than anterior cross-vein, and nearly thrice its own length distant from it; scales brown.

Legs black, unbanded; ungues of forelegs unequal, the larger uniserrate, mid-ungues unequal and simple, hind equal and simple.

♀. Similar to ♂. Palpi black-scaled, first segment with a few black bristles; clypeus black; antennæ brown; ungues all equal and simple; abdominal spots well defined.

Length: ♂, 3·5; ♀, 4 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from seven males and ten females, bred from larvæ. It is abundantly distinct from *L. annulata* Taylor, and *L. cylindrica* Theobald.

Two males and one female have the bases of the fork-cells almost level, but there are no other differences from the typical specimens.

LOPHOCERATOMYIA ANNULATA Taylor.

Proc. Linn. Soc. N. S. Wales, 1916, xli., p.571.

Hab.—Q.: Cairns (F. H. Taylor).

A single specimen, bred at the same time as *L. cairnsensis* mihi; it agrees with the type in all respects.

LOPHOCERATOMYIA CYLINDRICA Theobald.

Mon. Culicid., iii., p.202 (1903) [*Culex*], Pl. ix.; *op. cit.*, v., p.361 (1910); Edwards, Bull. Ent. Res., vii., p.228 (1917).

Hab.—Q.: Eidsvold (Dr. T. L. Bancroft).

I quite agree with Edwards in placing this species in *Lophoceratomyia*. It is typical in every respect. The figure of the head of the male on Plate ix., though small, shows the plates on the antennæ.

MANSONOIDES UNIFORMIS (Theobald).

Theobald., Mon. Culicid., v., p.448 (1910); Edwards, Bull. Ent. Res., ii., p.253 (1911).

Hab.—N. Territory: Darwin (G. F. Hill).—Q.: Eidsvold (Dr. Bancroft), Cairns, Townsville.—N.S.W: Newcastle (Dr. Dick).

This is a very abundant and widely distributed species, being found from Africa to the Philippine Islands, New Guinea across to Darwin, and extending as far as Newcastle, N.S.W.

FINLAYA POICILIA Theobald.

Mon. Culicid., v., p.464 (1910); Taylor, Proc. Linn. Soc. N. S. Wales, 1914, xxxix., p.465.

Hab.—Q.: Cairns (F. H. Taylor).

MOLPEMYIA PRIESTLEII (Taylor). (Plate lxxxii., fig.10).

Calomyia priestleii Taylor.

Trans. Ent. Soc. London, 1913, Part iv., p.684 (1914).

Calomyia cannot be retained as distinct from *Molpemyia*, there being no structural differences. The writer was in error in describing the scales on the centre of the head and bordering the eyes as spindle-shaped, as they are, in reality, only large *narrow-curved* scales.

The species seems to be somewhat variable, as a specimen, taken at a later date than the type, shows complete broad banding on the abdomen, whereas, in the type, the abdomen has large, basal spots on the segments.

SKUSEA PSEUDOMEDIOFASCIATA Theobald.

Mon. Culicid., v., p.489 (1910).

Hab.—Q.: Cairns (F. H. Taylor).

Two specimens, both males, before me, agree perfectly with the description of this species They were bred from larvæ. It was originally described from Ceylon.

URANOTÆNIA ALBESCENS Taylor.

Trans. Ent. Soc. London, 1914, Pt. i., p.705.

Hab.—Q.: Cairns (F. H. Taylor).

The fourth segment of the abdomen is more correctly described as brown, with a median, apical, white-scaled area. The Cairns specimens, bred from larvæ, show the fourth segment entirely black.

URANOTÆNIA CAIRNSENSIS, sp.n.

♀. Head with dusky-brown, flat scales, with a fairly broad band of bluish-white scales round the eyes; antennæ dark brown, basal lobe and base of first segment yellowish, palpi black; clypeus dark brown; eyes silvery; proboscis dusky-brown.

Thorax brown, with brown scales and black bristles; scutellum with flat, black scales; pleuræ with white, flat scales; there is a short, pre-alar, white line of scales.

Abdomen with dusky-brown scales, all the segments with lateral, white scales; venter with white scales.

Legs dark brown, femora pale beneath, ungues very small, equal and simple.

Wings longer than abdomen: first fork-cell shorter and narrower than second, latter considerably nearer the base of the wing, stem of first more than twice the length of its cell, stem of second slightly longer than its cell; anterior basal cross-vein longer than the anterior cross-vein, and nearly twice its length from it; halteres pale, with black knobs.

Length 1·5 mm. (vix).

Hab.—Q.: Cairns (F. H. Taylor; July, 1917).

Described from two specimens, bred from larvæ. It is easily separated from other Australian species by its venational and abdominal markings.

URANOTÆNIA TIBIALIS, sp.n. (Plate lxxxii., fig.11).

♂. Head clothed with white scales, except in the centre, where they are brown; antennæ brown, basal lobes black, basal half of first segment pale; palpi dark brown; eyes black; proboscis brown.

Thorax with brown scales, and long, black bristles, apparently in four rows; a short, pre-alar line of bluish-white scales; scutellum with brown scales, pleuræ brownish, with bluish-white, flat scales.

Abdomen covered with black scales; venter brown-scaled.

Wings longer than abdomen; first fork-cell shorter and narrower than second; base of latter much nearer the base of the wing; stem of the first nearly twice the length of its cell; stem of second about the length of its cell; anterior basal cross-vein longer than anterior cross-vein, and once and a half its length from it.

Legs dusky-brown, femora basally pale beneath; apex of fore-tibiæ with a tuft of long, brown, hair-like scales, second tarsal clothed with fairly long scales, tarsi three to five pale; ungues of forelegs simple, rectangular, mid apparently the same.

♀. Similar to male Scales on the costa, subcostal and first longitudinal veins dusky as in male. Fore-tibiæ normal.

Length: ♂, 1·75; ♀, 1·5 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from one male and two female specimens, bred from larvæ. The black abdomen, venation, and fore-tibiæ of the male render this species distinct from its Australian congeners. The lengths are only approximately correct, as the specimens are doubled up.

URANOTÆNIA PROPRIA Taylor.

Trans. Ent. Soc. London, 1914, Pt. iv., p.704.

♀. Similar to male. First fork-cell shorter and narrower than second; stem of former nearly twice the length of its cell, stem of latter slightly longer than cell, anterior basal cross-vein longer than anterior cross-vein, and once and one-half its own length from it. Legs normal.

Hab. Q.: Cairns (F. H. Taylor).

This species was, previously, only known from the male.

URANOTÆNIA ANTENNALIS, sp.n.

♀. Head with pale scales in the centre, blackish elsewhere; eyes black; antennæ brown, basal lobes yellowish, first segment very long, about twice the length of the second, its base pale; palpi blackish.

Thorax brown, with brown scales and black bristles, and a short, narrow, pre-alar, white line of scales; scutellum with black scales; pleuræ brown, with white scales.

Abdomen covered with black scales; venter brown-scaled.

Legs dusky-brown; femora pale beneath, apical tarsi pale.

Wings: first fork-cell shorter than second, stem of first fork-cell about twice and one-half the length of the cell; stem of the second slightly longer than the cell; anterior basal cross-vein longer than anterior cross-vein, and twice its own length from it; scales on the costa, subcostal, and first long vein dusky, paler elsewhere.

Length 1·75 mm.

Hab.—Q.: Cairns (F. H. Taylor).

Described from two specimens, bred from larvæ. The first joint of the antennæ, and the venation separate this species from other described Australian species.

URANOTÆNIA HILLI, sp.n. (Plate lxxxiii., fig.12).

♂. Head covered with brown, flat scales; antennæ pale, nodes brown; eyes black and silvery; palpi brown, slightly longer than usually found in the genus.

Thorax covered with dusky-brown scales, prothoracic lobes prominent, dark-scaled; scutellum dark, denuded of scales; pleuræ yellowish-brown.

Abdomen with black scales; venter pale-scaled.

Legs dark brown; femora pale beneath.

Wings: fork-cells the same length, base of the second nearer the base of the wing; stem of the first fork-cell slightly shorter than its cell, stem of second not quite one-third shorter than its cell; anterior basal cross-vein longer than the anterior cross-vein and about once and one-half its own length distant from it.

Length 2 mm.

Hab.—N. Territory: Darwin (G. F. Hill; No.321).

Described from two specimens. The length of the first fork-cell is relatively longer in comparison with the second than is found in *Uranotænia,* but I prefer to regard this species as belonging to that genus.

Mr. Hill notes "larvæ in crab-holes in mangrove-swamps." It affords me much pleasure to dedicate this species to its discoverer.

Paratype in Coll. Hill.

HODGESIA CAIRNSENSIS, sp.n. (Plate lxxxiii., figs.13, 14).

Head with black and bluish scales. Thorax orange, with prominent black markings. Abdomen black-scaled, fifth segment apically white, the second to sixth segments laterally white. Legs unbanded.

♀. Head with black scales, with a triangular patch of bluish-white scales on the occiput and on the sides towards the base; eyes, palpi, and proboscis black; antennæ black, first joint long, basal half yellowish.

Thorax orange, with a prominent black spot above the wing-roots, and a broad, median, brown stripe from the centre to the posterior margin of the scutellum, sparsely covered with short, hair-like scales; scutellum pale on the sides, covered with small, black scales; prothoracic lobes with pale, flat scales.

Abdomen with black scales, first segment paler, segments two to six with lateral, white patches, fifth with a broad, white-scaled, apical band, apex bristly; venter pale-scaled, apical segment dark.

Wings considerably longer than abdomen, black-scaled; first fork-cell longer and narrower than second, base of the latter a little nearer the base of the wing; stem of the first fork-cell about three-quarters the length of the cell, stem of second about two thirds of its cell; base of second long vein carried well beyond the transverse vein; halteres pale, with black knobs.

Legs black; femora with the basal half above, and the under-surface, creamy; ungues very small, equal and simple.

Length, 1·5 mm.

Hab. – Q.: Cairns (F. H. Taylor).

Described from a long series taken in shady situations, on th edges of swamps, mainly sheltering in tree-holes. It is readil distinguished from *H. triangulata* Taylor, by its thorax an abdominal banding.

Hodgesia triangulata Taylor. (Plate lxxxiii., fig.15).

Trans. Ent. Soc. London, 1914, Pt. i., p.204; Proc. Linn. Soc. N. S. Wales, 1915, xl., p.184.

Hab.—Q.: Cairns (F. H. Taylor).

Fresh specimens show that segments two, three, five, and six have white, lateral spots, and that the venter is white-scaled.

This species is wrongly recorded as *Hodgesia trimaculatus* in the Zoological Record, li., Insecta, xii., p.277, 1914 (1916).

EXPLANATION OF PLATES LXXX.-LXXXIII.

Plate lxxx.

Fig.1.—*Anopheles* (*Myzorhynchus*) *barbirostris* var. *bancrofti* (Giles); head of male.

Fig.2.—*Toxorhynchites speciosus* (Skuse); head of male.

Fig.3.—*Armigeres breinli* Taylor; genitalia of male.

Plate lxxxi.

Fig.4.—*Grabhamia theobaldi* Taylor; wing.

Fig.5.—*Culicada wilsoni*, sp.n.; head of male.

Fig.6.—*Culicada wilsoni*, sp.n.; genitalia of male.

Fig.7.—*Culicada wilsoni*, sp.n.; wing of female.

Plate lxxxii.

Fig.8.—*Lophoceratomyia cairnsensis*, sp.n.; head of male, showing antennary organs.

Fig.9.—*Lophoceratomyia cairnsensis*, sp.n.; wing.

Fig.10.—*Molpemyia priestleii* Taylor; wing of female.

Fig.11.—*Uranotænia tibialis*, sp.n.; wing.

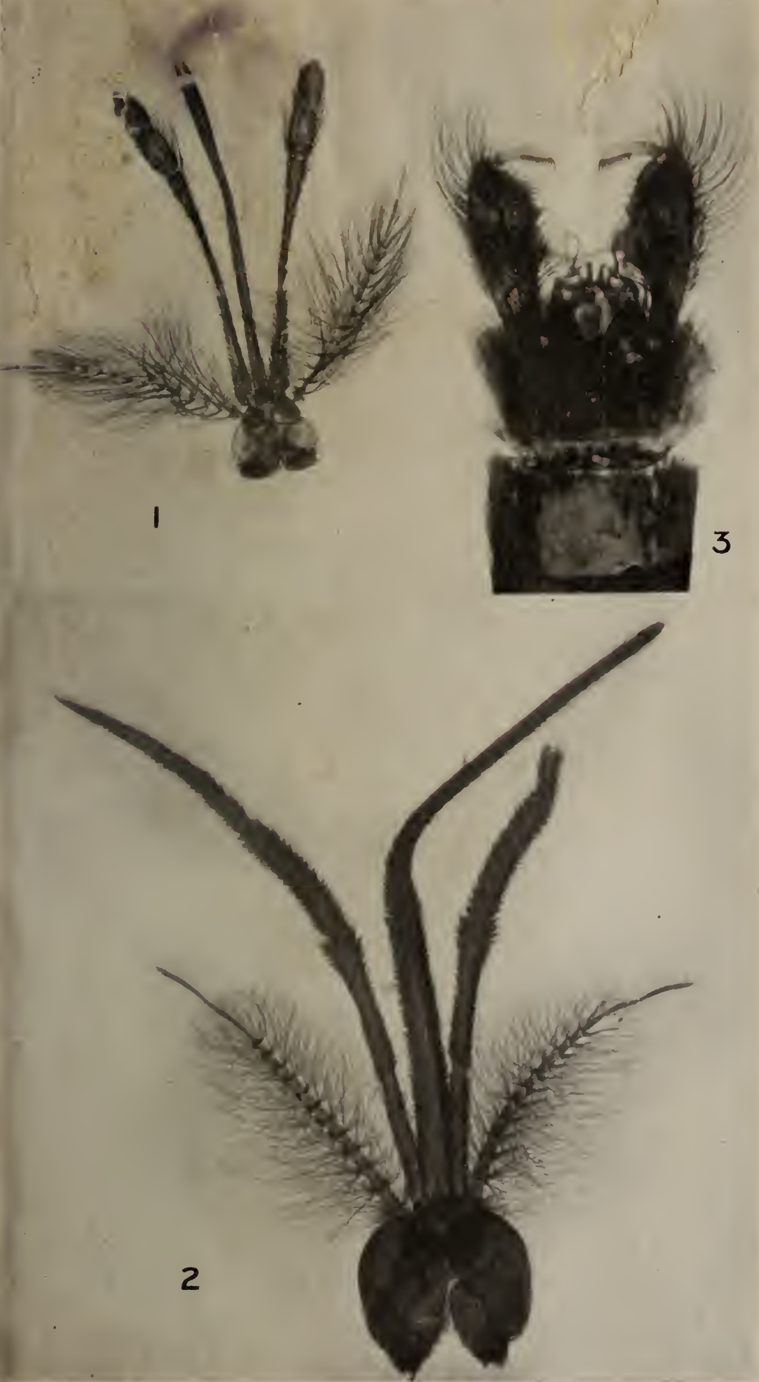
Plate lxxxiii.

Fig.12.—*Uranotænia hilli*, sp.n.; wing.

Fig.13.—*Hodgesia cairnsensis*, sp.n.; wing.

Fig.14.—*Hodgesia cairnsensis*, sp.n.; portion of wing under high power.

Fig.15.—*Hodgesia triangulata*, sp.n.; wing.



1. *Anopheles barbirostris* v. *bancrofti* (Giles). 2. *Toxorhynchites speciosus* (Skuse).
3. *Armigeres breinli* Taylor.

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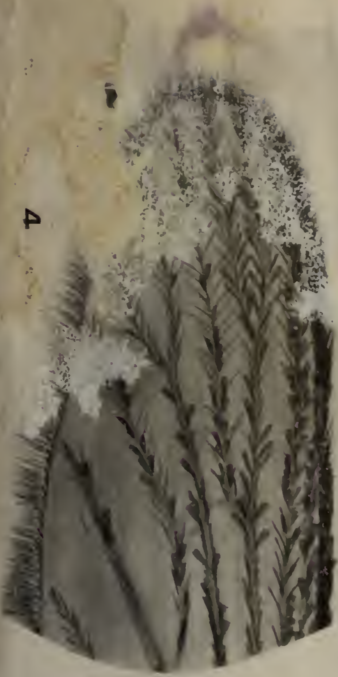

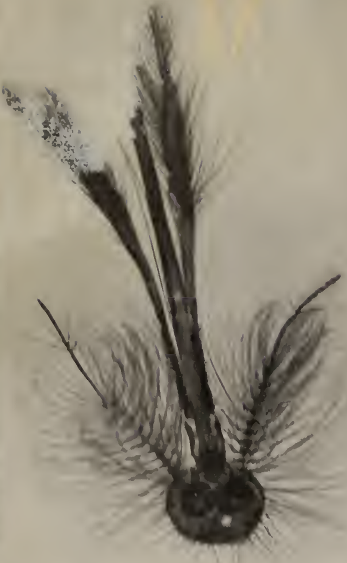

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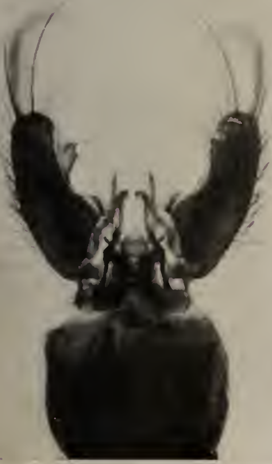

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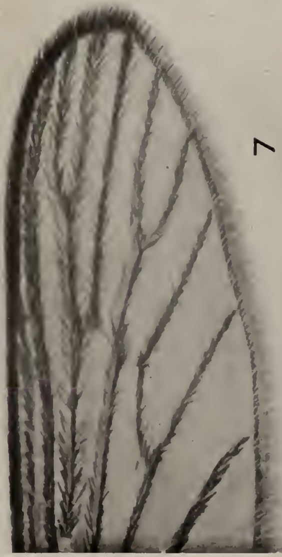

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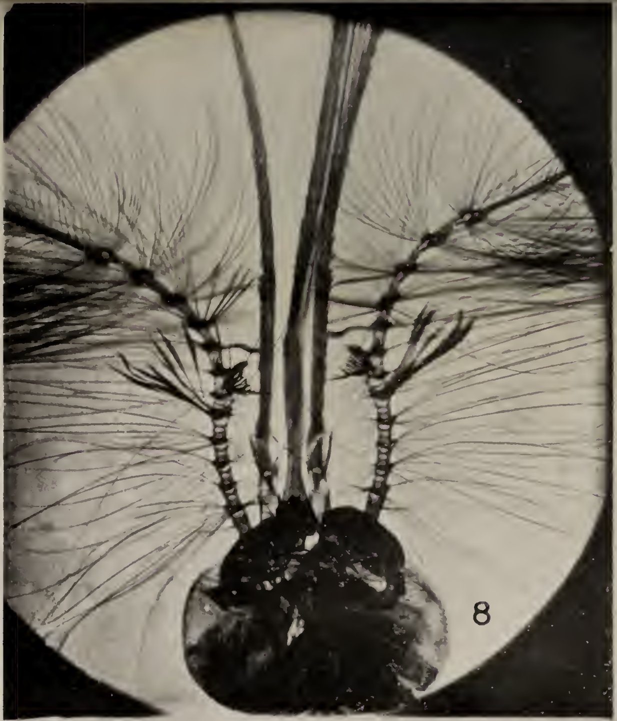
4. *Grabhamia theobaldi* Taylor. 5-7. *Culicada wilsoni*, sp. n.



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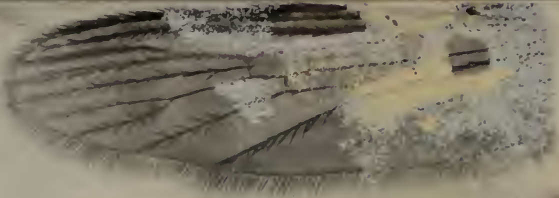

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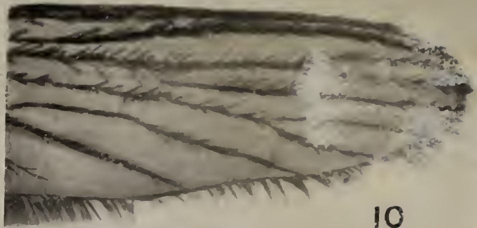

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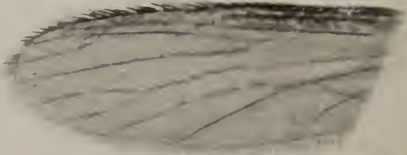

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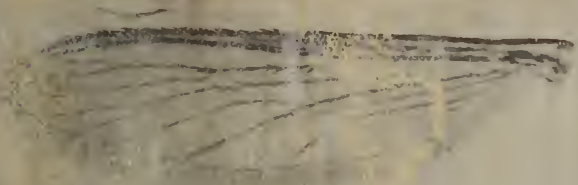
8-9. *Lophoceratomyia cairnsensis*, sp. n.

10. *Molpemyia priestleii* Taylor.

11. *Uranotænia tibialis*, sp. n.



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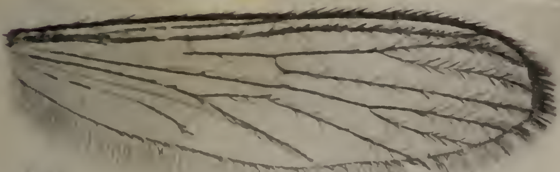

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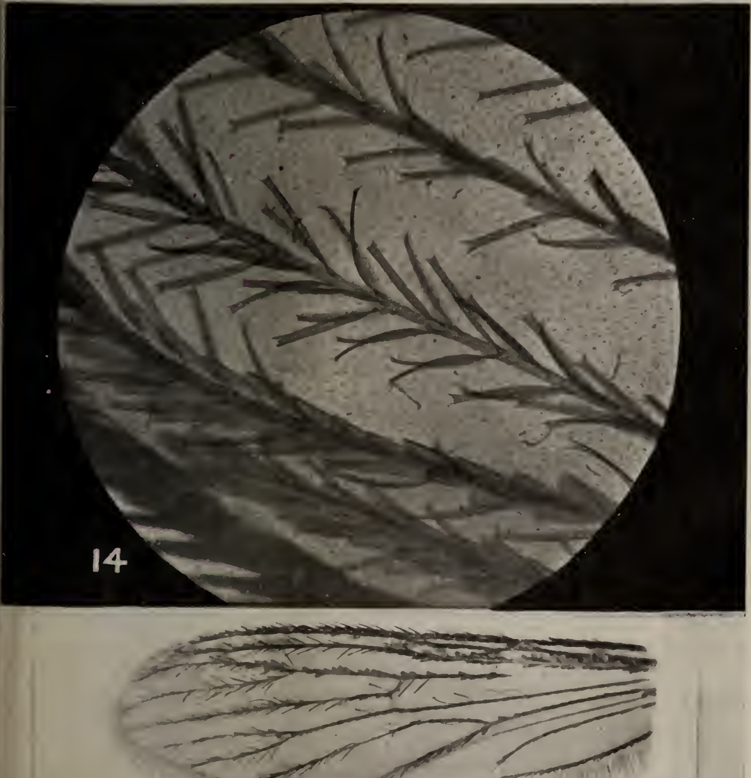

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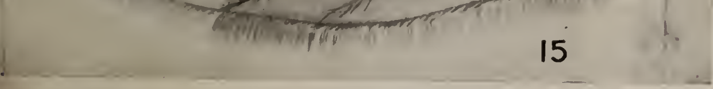

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12. *Uranotænia hilli*, sp. n. 13-15. *Hodgesia triangulata* Taylor.

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XXXVI. STUDIES IN THE ANTITRYPTIC ACTION OF BLOOD SERUM.

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Since Hahn [1897] first definitely observed that the blood serum of normal animals produced an inhibitory action upon the digestive power of trypsin, many investigations have been made into this property, both as regards the nature of the action, and of the particular constituents of the serum which cause it, and as the result several theories have been advanced.

One represents this action as due to the presence in the serum of a true antibody in Ehrlich's sense, analogous to an antitoxin. In support of this numerous statements have been made by Achalme [1901], Jochmann and Kantorowicz [1908], Meyer [1909, 1, 2] and others, that the antitryptic power of the serum of an animal is increased as the consequence of the injection of trypsin into the animal. Meyer [1911] even goes so far as to attribute the presence of antitrypsin in serum to the proteoclastic ferments in the tissue cells acting as antigens, a view which has been reasserted more recently by Stawraky [1914]. The literature however contains much contradictory evidence upon this point, many workers having failed to confirm this increase in antitryptic power after injecting trypsin [Landsteiner, 1907; Doblin, 1909; Rosenthal, 1910, etc.]. Another explanation was given by Rosenthal [1910], who considered that the inhibition could be entirely accounted for by the presence of the products of proteoclastic action. This conclusion, however, was based upon experiments which were not very convincing, and may be dismissed as extremely unlikely; for although the products of a trypsin digest do hinder the action of the enzyme [Bayliss, 1904], yet it is only to a slight extent [Walters, 1912], whilst a very small quantity of serum is capable of producing a very marked inhibition, far too large to be accounted for in this way. Moreover, the antitryptic power of serum is not removed by dialysis, as would be expected if it were due to amino-acids and other products of protein hydrolysis [Meyer, 1909, 1, 2; Cathcart, 1904; Stawraky, 1914].

The view which has been most generally accepted was put forward by [Hedin 1905; 1906, 1, 2; 1907], who attributed the antitryptic action to the adsorption of the enzyme by some constituent of the serum, and pointed out the similarity of the action of serum upon trypsin to the inhibition of tryptic digestion produced by the addition of animal charcoal.

With regard to the nature of the antitryptic substance in the serum, it was shown by Cathcart [1904] that this property was associated with the albumin fraction of the serum, since on fractionating the serum with ammonium sulphate the antitryptic power was retained by the albumin fraction alone, the other serum proteins being quite inactive. Later investigators have attributed the action to lipoids [Schwarz, 1909] on account of the loss of this power when serum is extracted with chloroform. Jobling and Peterson [1914] consider that it is due to the presence of unsaturated fatty acids which may be extracted from the serum by ether or chloroform, by which means they obtained an extract which possessed an actively antitryptic action. They also found that soaps of unsaturated fatty acids obtained from various sources possessed the property of inhibiting antitryptic digestion.

The antitryptic power of serum has been stated to be increased in certain diseases [Brieger and Trebing, 1908; von Bergmann and Meyer, 1908; Hort, 1909; Golla, 1909, etc.], notably in cancer, in certain acute infections such as pneumonia and typhoid fever, in certain chronic infections such as tuberculosis and syphilis, and in severe anaemias, and suggestions have been made to employ this power as a clinical test. This possibility, with the additional hope, no doubt, of a clue to the cancer problem, has inspired a large amount of research in this direction, and methods have been devised by which the antitryptic power of different sera may be compared quantitatively, the comparison with a normal serum being termed the antitryptic index of the serum.

The methods generally used for obtaining this index are the Loeffler plate method, and the Fuld-Gross method. In the former an increasing series of drops of serum are added to a drop of trypsin placed on a surface of coagulated protein, the whole is incubated and the antitryptic index determined from the relative number of drops required just to prevent the trypsin from digesting away and pitting the underlying protein surface. It is obvious that this method is very inaccurate since it is almost impossible to judge whether the surface is indented or not.

In the Fuld-Gross method a definite quantity of caseinogen is employed as substrate, and to this is added such an amount of trypsin as will in a given time digest it to such an extent that the addition of a mixture of alcohol and acetic acid just fails to produce a precipitate. To this mixture of caseinogen and trypsin, a definite amount of serum is added and the antitryptic index is obtained by finding how much more trypsin has to be added to digest the caseinogen to the same degree as before in a given time. This method is not capable of any great accuracy since it depends upon an end point reaction, so that when the quantity of substrate (caseinogen) falls below a certain level the rate of digestion is diminished.

To overcome this Golla [1909] employed a method in which equal ferment strengths were allowed to act on a substrate (caseinogen) to which equal units of normal serum and the serum under examination had been added, and continuous observations were made of the amount of caseinogen digested, either by measuring the increase in electrical conductivity, or the loss in viscosity of the mixtures. This method, however, can only give approximately quantitative results when the two sera under comparison have almost the same action, since Hedin [1906, 1] has shown that small quantities of serum produce a relatively larger effect than large quantities, and therefore when two widely different sera are compared the result will depend upon the quantity of the sera employed for the comparison.

In the course of some experiments upon the antitryptic action of serum it became necessary to compare the action of various sera on trypsin and the unsatisfactory methods usually employed made it desirable to reinvestigate the question of the comparison of two sera using more accurate methods of measuring the antitryptic action than those generally employed.

Comparison of the antitryptic action of sera.

Methods employed.

In these experiments equal quantities of a solution of caseinogen (3 per cent. in 0·2 per cent. sodium carbonate) were warmed in a water thermostat at 37° until the temperature of the bath was attained, and the trypsin and serum were then added in the required quantities. After a definite time the quantity of caseinogen digested was estimated by the method used by Hedin [1905] in which a known volume of tannic acid solution was added, the mixture allowed to stand for twelve hours, and the nitrogen determined in a known volume of the filtrate by the Kjeldahl method. The difference between the nitrogen which escapes precipitation with tannic acid before and after the incubation gives a measure of the digestion. As all results are comparative the numbers given in the experiments detailed below represent cc. of $N/10$ acid corresponding to the ammonia distilled off in the Kjeldahl. All the digestions were carried out in the presence of 0·5 cc. of toluene. In each case care was taken to have such an excess of caseinogen present that the action was directly proportional to the amount of active enzyme, whilst the digestions were only extended over short intervals of time, so that the caseinogen available should not fall sufficiently low to affect the rate of hydrolysis. The enzyme solutions employed were a commercial sample made by Fairchild Brothers and Forster, and preparations made by digesting minced ox or sheep pancreas at 37° in the presence of toluene and chloroform for two or three days, filtering, further digesting the filtrate, and dialysing away the products of digestion against running water. These solutions gave only a faint cloudiness with tannic acid, and only a very faint biuret reaction.

Effects of varying the amount of serum.

It was stated by Hedin [1906, 1, 2] that if trypsin and serum were mixed before being added to the substrate, the neutralising effect of the antibody was larger than when they were added separately; moreover the longer the mixture was kept before being added to the substrate, the greater, up to a certain point, was the amount of trypsin neutralised. Thus the adsorption of the enzyme required a certain time to attain its maximum. From this it seemed probable that if trypsin and serum were added together to caseinogen, the rate of digestion would gradually decrease. The following experiment was done to see if such were the case, goat serum being employed.

The mixtures *A*, *B*, and *C* were incubated at 37°, and 50 cc. of each removed at the intervals stated, 30 cc. tannic acid added and the nitrogen estimated in 60 cc. of the filtrate; the increase in nitrogen is given in cc. 0·1 N acid.

A. 250 cc. caseinogen, 7·0 cc. water, 2 cc. trypsin (ox pancreas).
B. 250 ,, 6·5 ,, 2 ,, 0·5 cc. serum
C. 250 ,, 6·0 ,, 2 ,, 1·0 ,,

Time hours	Total			Rate per hour during preceding interval		
	A	B	C	A	B	C
1	3·4	2·2	1·6	3·4	2·2	1·6
2	6·4	4·2	2·7	3·0	2·0	1·1
4	12·8	8·0	4·7	3·2	1·9	1·0
8	—	15·6	9·0	—	1·9	1·1

The digestion of the caseinogen proceeded in each case at a rate constant within the error of experiment excepting perhaps for a slight irregularity in the first hour after mixing the solutions.

Under these conditions, therefore, a definite rate of reaction may be obtained.

Hedin found that small quantities of serum had a relatively larger inhibitory effect upon the action of trypsin than large quantities; moreover he observed that no amount of serum was able completely to prevent the action of the trypsin. In the experiments quoted however only a few different concentrations of serum were employed. The following experiments were carried out with a large number of concentrations of two sera of different origin to observe the course of the inhibition in each case, and to ascertain whether a definite quantitative comparison of the two sera could be obtained.

Sheep and dog serum were employed.

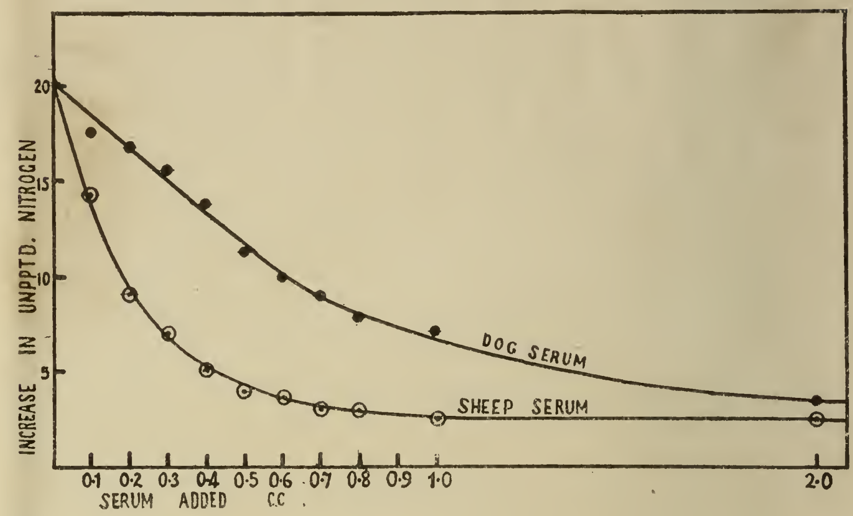
Each mixture consisted of 50 cc. caseinogen solution previously warmed to 37°, 2 cc. trypsin and *N* cc. serum, the total volume being made up to 55 cc. with water. After four hours 30 cc. of tannic acid were added and the nitrogen determined in 70 cc. of the filtrate. The results are given in the following table.

	Serum added in cc.	Soluble nitrogen produced	
		Sheep serum	Dog serum
1	0	20·4	20·4
2	0·1	14·5	17·8
3	0·2	9·1	17·1
4	0·3	7·0	15·6
5	0·4	5·2	13·8
6	0·5	4·1	11·5
7	0·6	3·7	10·0
8	0·7	3·3	9·0
9	0·8	3·2	8·0
10	1·0	2·6	6·1
11	2·0	2·6	3·7
12	3·0	2·7	3·9

1 cc. trypsin in the same volume in absence of serum gave 10·1 cc., showing that the rate in the absence of serum was proportional to the quantity of trypsin present, and that therefore an excess of caseinogen was present in every case.

From these results it is seen that with increasing amounts of serum the relative inhibition produced by each successive addition gradually falls off, until a point is reached beyond which further additions produce no effect and the curve runs parallel to the base line. Complete inhibition cannot be produced.

The figures are shown graphically on the accompanying diagram.



They show further that the sheep serum produced a much greater inhibitory effect than did the dog serum, both in the early stages and in the final rate. It is apparent, however, that a quantitative comparison of the actions of the two sera cannot be obtained by adding a definite amount of serum to a trypsin digest and comparing the action, since the comparison depends upon which part of the curves representing the reaction are used.

A similar experiment was done with another sample of trypsin to try the effect of very small quantities of serum. The sheep serum was diluted ten times with water, and the dog serum with an equal amount of water.

In each case 2 cc. trypsin were employed and 50 cc. caseinogen, the total volume being 55 cc. The mixtures were incubated for four hours at 37°. The figures in the first column give the volumes of undiluted serum contained in the mixtures.

Serum added cc.	Soluble nitrogen produced	
	Sheep serum	Dog serum
0	11·8	11·8
0·02	12·2	—
0·04	11·6	12·5
0·05	—	12·5
0·06	10·3	—
0·08	9·5	—
0·10	8·6	12·3
0·15	6·5	—
0·20	4·9	11·8
0·25	3·6	—
0·4	—	9·2
1·0	—	4·0

1 cc. trypsin in absence of serum gave 5·5 cc.

The experiment shows that with very small quantities of serum very irregular results were obtained. In fact no definite inhibition was observed with the sheep serum until 0·06 cc. had been added, whilst with the dog serum small quantities produced a slight rise. This may be due to the reaction of the serum since a similar slight rise was produced by adding a very dilute mixture of phosphates so that the mixture when diluted to the same volume as the digest gave the same tint with a suitable indicator, as did 0·05 cc. of serum diluted to the same volume.

The action of the same sample of serum upon two different trypsin solutions of the same digestive power.

During the experiments certain discordant results seemed to point to the fact that the different solutions of trypsin were not always inhibited to the same extent by a single specimen of serum, even when the two solutions of trypsin in the absence of serum were capable of digesting the same quantity of caseinogen in the same interval of time. Experiments were carried out therefore upon this point.

I. One sample of trypsin (1) was prepared from ox pancreas, whilst the other (2) was a commercial preparation of Fairchild's trypsin.

The required volumes of the two trypsin solutions which digested the same amount of caseinogen in the same time were determined in preliminary experiments, which also showed that the quantity of caseinogen was such as not to influence the rate of reaction. In each case 50 cc. of caseinogen were employed, the total volume being made to 60 cc. Sheep serum was used and the mixtures incubated at 37° for five hours.

	Digestion with	
Serum added cc.	Trypsin 1 1·45 cc.	Trypsin 2 1 cc.
0	20·0	19·9
0·1	14·1	10·0
0·2	10·3	7·0
0·5	5·0	4·3

II. A similar experiment was carried out with two different samples of trypsin from ox-pancreas and sheep serum—five hours at 37°.

	Digestion with	
Serum added cc.	Trypsin A 2 cc.	Trypsin B 1·6 cc.
0	17·6	17·7
0·1	13·1	11·3
0·2	11·0	7·1
0·5	5·9	4·0

III. A similar experiment with goat serum and two specimens of trypsin (ox pancreas)—three hours at 37°.

Serum added cc.	Trypsin C 4 cc.	Trypsin D 1 cc.
0	12·5	12·6
0·2	8·2	7·6
0·4	5·7	5·7
0·6	4·6	5·0
2·0	3·6	3·5

IV. A similar experiment with goat serum and two more trypsin preparations from ox pancreas—three hours at 37°.

Serum added cc.	Trypsin E 0·7 cc.	Trypsin F 2·6 cc.
0	16·0	16·5
0·2	12·2	12·0
0·4	9·8	10·3
0·6	7·4	8·9
1·0	4·8	7·3
4·0	4·8	7·3

In experiments I and II the two trypsin solutions in the absence of serum digested the same quantity of caseinogen, yet the effect of adding varying quantities of the serum to each was very different. On the other hand in experiment III the effect on the two preparations was practically the same. In experiment IV, again, a considerable difference was noticed as the quantity of serum was increased.

These experiments show, therefore, that equal quantities of a serum may not always produce the same inhibitory effect upon different preparations of trypsin although the enzyme solutions have the same proteoclastic power as measured by the digestion of caseinogen.

In obtaining the antitryptic index of a serum a sample of enzyme is generally employed of such a strength that it will just digest away a given amount of caseinogen in a given time, as in the Fuld-Gross method. As shown above the effect of serum upon this may vary with the particular sample of enzyme used, and it is obvious therefore that the comparison of the antitryptic action of a different serum made at different times with different trypsin preparations, even though of standard strength, may yield erroneous results, and many of the contradictory results found in the literature may probably arise in this way.

From these experiments the conclusion must be drawn that the antitryptic action of the two sera may be compared only by observing the effect of varying quantities of each upon the same sample of trypsin, and that only a qualitative comparison is then possible.

Is this action due to the presence of zymoid in the enzyme preparations?

The different inhibitory powers of the same serum upon different preparations of trypsin might be explained by the presence in the solution of enzyme so altered that it is incapable of digesting caseinogen but is yet able to enter into association with the inhibitory substance in the serum. Evidence of the existence of a modified enzyme which would still combine with antibody but had lost the power of clotting milk, has been put forward by Korschun [1902] in the case of rennet, whilst Bayliss [1904] obtained facts which suggested the production of a similar modification of trypsin by warming to 25° for a day or two. For these modifications Bayliss suggested the name of zymoid. Furthermore Bearn and Cramer [1907] stated that when trypsin was heated to about 50° or 60° the presence of a zymoid was apparent. Experiments were carried out therefore, to see if trypsin could be altered in this manner by heating.

A solution of the trypsin was heated for two hours at 60°, and thus rendered inactive; the addition of this to a mixture of caseinogen, trypsin and serum was without effect upon the quantity of caseinogen digested. Solutions of trypsin were kept at different temperatures, between 30° and 40° for varying times so as to lessen their activity, and quantities of each of similar digestive power to a given volume of the original trypsin, were tested upon caseinogen in the presence of varying quantities of the same serum. In every case it was found that the power of associating with the serum was lost in proportion to the loss of activity. No evidence therefore could be obtained of the presence of zymoid.

Variations in the antitryptic action of serum.

As already stated the antitryptic action of serum has been proposed for diagnostic purposes in disease, a proposal which assumes that the sera of normal animals of the same species have the same inhibitory action upon trypsin. On the other hand it has been contended that considerable variations do occur in the action of normal serum even in the same animal.

In the following experiment the inhibitory action of the serum from three dogs was compared to see if naturally occurring differences could be found. To avoid errors due to different trypsin preparations, the digestions were carried out at the same time using the same trypsin solution. Parallel series of mixtures were incubated for three hours at 37°, and the extent of digestion of the caseinogen measured as before. Each mixture contained 50 cc. caseinogen, 5 cc. trypsin and varying amounts of fresh serum, the total volume being constant. The results are given in the table.

Two of the dogs (1 and 2) were young dogs, about four months of age, and the third was a fully grown female. For comparison also the action of the serum of a goat is given.

Serum added	Soluble nitrogen produced			
cc.	Dog 1	Dog 2	Dog 3	Goat
0	12·6	12·6	12·6	12·6
0·2	10·4	9·6	10·2	8·2
0·4	7·6	7·2	7·6	5·7
1·0	5·1	5·2	5·5	4·0
2·0	4·2	4·2	4·4	3·4
3·0	4·1	4·0	4·2	3·2

The inhibitions produced by the sera from the three dogs were thus substantially the same in every case; the goat serum, however, showed a more marked difference from the others; in an earlier experiment we have already seen that serum from dog and sheep were different in their behaviour.

ATTEMPTED IMMUNISATION AGAINST TRYPSIN.

The question whether the injection of enzyme into an experimental animal is followed by the production of true antibodies has given rise to a considerable amount of work. It has been pointed out by Bayliss [1914, p. 127], that the evidence tends to show that enzymes are not proteins, and as it is very doubtful whether any other substances are capable of acting as antigens and producing antibodies when injected into living organisms, these are *prima facie* grounds for doubting the capacity of enzymes to act as antigens.

The first "anti-enzyme" was described by Hildebrandt [1893], who stated that the injection of emulsin into animals was followed by the appearance in the serum of the power of inhibiting the action of emulsin on glucosides. Bayliss [1912], however, found that this action was due to the diminution of acidity of the mixture, and he showed that when the hydrogen ion concentration was brought back to its original value the effect disappeared, whilst the same inhibitory effect could be produced by making the emulsin to the same hydrogen ion concentration as that produced by adding the immune serum. In the case of the "anti-rennet" produced by immunising animals with rennet, Hedin [1911, 1912] states that it is not a true antibody, whilst Thaysen [1915] says that it may be completely accounted for partly by adsorption of the enzyme, and partly by the effect of change of hydrogen ion concentration.

In the case of trypsin, as stated earlier, many statements have been made to show that an antitrypsin can be produced by the injection of the enzyme, whilst on the other hand there are recorded numerous failures to obtain it. In the case of trypsin the difficulty lies in the presence of the antitryptic property in normal serum. In reviewing the literature it appeared probable that many of the contradictory results might be accounted for by several causes. In many cases the "immune" sera from the experimental animals were tested against the serum of a normal animal of the same species, and it is possible that the antitryptic power of normal animals might vary with the individual. On the other hand, if the blood of the same animal were employed and its antitryptic activity tested before and after injection, the tests would be made usually by the Fuld-Gross method with the fresh serum and thus at different times and possibly with different specimens of trypsin. The latter although of standard activity as regards action on the substrate, might, as has already been shown, be adsorbed to a different degree by the serum, so that it might appear as if the activity of the serum had been altered. In the following experiments attempts have been made to avoid these difficulties by testing the serum of the animal before and after injection against the same trypsin solution. The solutions of trypsin used for injection were rendered as sterile as possible by keeping them for a day or two in the presence of toluene, the latter being then removed by a rapid current of air previously passed through sterile cotton wool. Before the injections were made the experimental animal was bled generally twice with an interval of a week, to obtain two samples of normal serum, which were preserved as described below. The solutions were then injected intravenously, several injections being made at suitable intervals. After a certain time the animal was again bled and the serum collected. In this way two specimens were obtained of the normal serum of the animal for comparison with the serum of the same animal after immunisation, the object being to try their inhibitory effect upon the same sample of trypsin, and to ascertain whether any difference in activity was produced and if so whether this difference was greater than such difference as might exist between the two samples of normal serum. In each experiment the antitryptic action of the serum was tested against the same trypsin preparation as was used for the injection. The sera as they were obtained were dried rapidly by the method recommended by Chapman [1905]. This was done by spreading 10 cc. over the surface of a tared flat glass dish, which was then kept in an evacuated desiccator containing sulphuric acid and placed in an incubator at a temperature of 37°. Within 24 hours the serum dried up. The dish and contents were then weighed and the dried mass powdered and preserved in a dry atmosphere[1] in the ice chest until required, when the powder was dissolved in water and made up to the volume of the original serum from which it had come. The serum when preserved in this manner retains its activity for a long time. In every case the sera were neutralised to litmus paper by the addition of sodium dihydrogen phosphate, before being tested. The tests were made by adding an increasing series of quantities to mixtures of trypsin and caseinogen, incubating at 37°, precipitating with tannic acid, and estimating the nitrogen in the filtrate. The following experiments with the same samples of serum dried and undried show that the drying had not produced any appreciable effect upon the antitryptic activity. The undried serum was kept on ice during the time taken in the drying of the other portion.

I. Each mixture consisted of 25 cc. caseinogen, 1·2 cc. trypsin (sheep pancreas), and varying amounts of the serum, the total volume being made to 30 cc. with water. After 18 hours at 37°, 15 cc. of tannic acid were added to each and the nitrogen estimated in 20 cc. of the filtrate. In the absence of serum 30·2 cc. were obtained.

Serum added	Digestion with	
cc.	Dried serum	Undried serum
0·5	6·0	6·0
1·0	3·6	4·0
2·0	3·1	3·2

II. A similar experiment with 1·2 cc. trypsin (ox pancreas) and sheep serum. In the absence of serum the digestion corresponded to 24·5 cc.

Serum added	Digestion with	
cc.	Dried serum	Undried serum
0·05	22·7	23·1
0·10	21·7	21·3
0·30	14·1	13·9
0·50	10·1	10·1
1·00	6·1	6·4

III. A goat (I) was injected intravenously at weekly intervals with the following quantities of trypsin (commercial sample of Grübler) dissolved in

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[1] On several occasions the serum powder when preserved for some time without special precautions being taken to keep it dry, was found to have become partially insoluble in water. Professor Chapman has informed me that he has noticed the same thing, and he attributes it to the effect of moisture which causes the proteins of the serum to coagulate. This was confirmed by an experiment in which two portions of the same serum powder were preserved, the one in a desiccator containing calcium chloride, and the other in moist air. In the latter case the serum soon became insoluble, whilst in the former it remained perfectly soluble. When precautions were taken to keep the powders dry this insolubility was never observed.

70 cc. of normal saline in each case; 0·4, 0·4, 0·4, 0·6, 1, 1, 1, 1, 1, g. After another week a sample of serum was obtained. Two samples of normal serum were collected before the injections for comparison. The results are given in the following table. Each mixture contained 25 cc. caseinogen, 5 cc. trypsin (1 g. in 50 cc.) and the quantities of serum given below, the total volume being constant.

	Digestion in the presence of serum		
Serum added	Before 1	Before 2	After injection
0·5	17·0	17·4	18·0
1·0	10·1	10·3	10·5

In absence of serum digestion = 28·6.

IV. A goat (II) received five intravenous injections of trypsin solution prepared from ox pancreas, 5, 7·5, 10, 20, 20 cc. being injected at weekly intervals. Two samples of normal and one of "immune" serum were collected.

The action on the enzyme is given below, each mixture containing 2·5 cc. trypsin, 25 cc. caseinogen and varying amounts of the serum. The mixtures were incubated at 37° for 18 hours.

Serum added cc.	Digestion in presence of serum		
	Before 1	Before 2	After injection
0·5	9·1	8·7	9·4
5	2·5	2·4	3·1

In the absence of serum 18·8 cc. were obtained.

V. A goat (III) received three injections intravenously of 20 cc. of trypsin (ox pancreas). Only one sample of normal serum was used. To test the antitryptic activity 2·5 cc. trypsin and 25 cc. caseinogen were digested with the sera, as given below, at 37° for 18 hours.

Serum added cc.	Digestion in the presence of serum	
	Before	After injection
0·01	18·0	18·0
0·05	17·5	17·5
0·10	16·7	16·5
0·25	15·2	14·6
0·50	10·1	9·1
1·00	6·1	5·7

In the absence of serum 18·9 cc. were obtained.

VI. In this experiment a goat was injected intraperitoneally with 20 cc. of trypsin (ox pancreas) on three successive days and was bled after seven days. The injections were not followed by any untoward results in the animal. The mixtures for testing the sera contained 2·5 cc. trypsin, 25 cc. caseinogen and varying amounts of serum, and were kept at 37° for 16 hours.

Serum added cc.	Digestion in the presence of serum Before 1	Before 2	After injection
0·01	18·4	18·1	18·2
0·05	16·8	16·4	17·5
0·10	15·9	15·2	16·3
0·25	10·6	11·0	13·0
0·50	6·5	6·2	6·2
1·00	5·0	4·8	4·5
2·50	4·7	4·6	4·1
5·00	3·9	3·1	3·4

In absence of serum 18·9 cc. were obtained.

Intraperitoneal injection had produced no increased antitryptic action.

The following two experiments were made upon sheep with a sample of trypsin prepared from the pancreas of an animal of the same species.

VII. A sheep (I) was injected intravenously at weekly intervals with 40, 70, 75 cc. of trypsin solution (sheep pancreas). The mixtures for testing the sera containing 1·2 cc. trypsin, 25 cc. caseinogen and varying volumes of serum were incubated at 37° for 18 hours.

Serum added cc.	Digestion in the presence of serum Before 1	Before 2	After injection
0·5	16·2	17·6	16·0
1·0	3·2	3·3	4·0
2·0	2·9	3·1	3·1

In absence of serum—30·2 cc.

The animal then received two further injections of 75 and 175 cc. trypsin.

Serum added cc.	Digestion Before	After injection
0·1	24·8	24·0
0·5	17·7	18·6
1·0	5·9	5·1
2·0	3·0	3·3

In the absence of serum = 29·0 cc.

VIII. A sheep (II) was injected intravenously with a solution of trypsin from sheep pancreas receiving the following doses at weekly intervals—40, 70, 75, 75 cc.

Serum added cc.	Digestion in presence of serum Before 1	Before 2	After injection
0·1	26·5	26·5	26·0
0·2	20·1	24·0	24·4
0·4	19·6	20·5	21·0
1·0	10·3	10·5	11·6
2·0	5·9	6·1	6·3

In absence of serum = 30 cc.

A further injection of 200 cc. of a fresh preparation from sheep pancreas was then given and the serum collected after 14 days and tested against the original normal serum.

Serum added	Digestion	
cc.	Before 1	After injection
0·1	8·3	9·1
0·25	4·7	4·8
0·50	4·5	4·4
1·00	4·5	4·5
1·50	4·2	4·1

In absence of serum = 23·4 cc.

In all these experiments there was no greater difference observed between the antitryptic action of the serum of the animals before and after the injections, than was found between the two samples of serum from the same animal before injection. There was therefore no evidence of the production of any antitrypsin by the injection of the enzyme.

These experiments were extended by examining the sera of the animals to see if the injections had given rise to the formation of a specific precipitin. The serum of goat (I) gave no precipitate when mixed with the trypsin solution used for the injection; on the other hand, after the injection of the trypsin the serum gave a precipitate with dilutions of the trypsin down to 1 in 1000.

The serum of goat (II) injected with ox pancreas trypsin before injection gave no precipitate with the trypsin solution. After injection, however, it gave a distinct precipitate when mixed with the trypsin solution in dilutions down to 1 in 100.

Similarly with goat (III) intraperitoneal injections with trypsin (ox pancreas) produced a faint precipitin reaction.

The sera of the two sheep before injection were also compared with the sera obtained after the final injection of trypsin. On mixing with the solution of trypsin employed, a distinct precipitate was noticed in the presence of 1/100 and 1/1000 respectively of enzyme solution,*whereas with the normal sera the mixture remained quite clear.

The last two cases are of interest as an instance of a precipitin being produced by injecting the extract of the pancreas of an animal of the same species.

From these results it is seen that although there was no increased antitryptic power observed in the serum due to the injection, yet a precipitin was produced. They thus show a similarity to the experiments quoted by Bayliss [1912] with emulsin where a precipitin was also produced when enzyme preparations were injected, although he was able to demonstrate that no true antibody to the enzyme was produced at the same time, and a similar conclusion must be drawn here as was done by Bayliss that the antigen to this precipitin was most probably some protein accompanying the trypsin and not the enzyme itself. These experiments contain therefore additional evidence that the enzyme trypsin is not a protein.

The results obtained do not bear out the statement of Porter [1914] that trypsin is inhibited by a specific precipitate. In her case the effect was compared of adding egg white to a mixture of trypsin and serum from a rabbit immunised with egg white, with that produced by adding egg white to a mixture of trypsin and normal serum. The differences shown were exceedingly small however, and no attempt was made to ascertain whether they could not be accounted for by changes in alkalinity of the mixture.

SUMMARY.

The observations herein recorded confirm those of Hedin and show that when increasing amounts of blood serum are added to a mixture of trypsin and excess of caseinogen the inhibitory effect on the trypsin, produced by equal increments of serum, decreases as the total quantity of serum present gets larger, until a point is reached beyond which the further addition of serum produces no further decrease in the action of the enzyme. In no case was it found possible completely to inhibit the action of trypsin by the addition of serum.

Different preparations of trypsin of equal digestive power upon caseinogen are not always inhibited to the same extent by the addition of equal quantities of the same serum.

Experiments to ascertain whether this was due to the presence of a zymoid—*i.e.* altered enzyme which had lost its power of hydrolysing caseinogen but was still able to form an association with the antibody in the serum—were unsuccessful.

The experiments show that in making a comparison of the effect of different sera upon trypsin, it is necessary to employ the same individual preparation of trypsin, and even then only a qualitative result is possible. The so-called antitryptic index, therefore, is not a definite constant for a serum.

In the experiments quoted in this paper the sera of normal animals of the same species did not show any marked variations in "antitryptic action," nor was any great change observed in the serum drawn at different times from the same animal; on the other hand, marked differences were observed between the actions of the serum from different animals (goat, sheep, dog).

It is shown that the possible errors in the methods usually employed for

comparing the effect of sera upon trypsin may account for the contradictory results obtained by so many workers upon the question whether the injection of trypsin into experimental animals is followed by an increase in the antitryptic action of the serum.

Experiments are recorded in which attempts were made to increase the antitryptic action of the serum of an animal by injecting the enzyme intravenously or intraperitoneally, precautions being taken in testing the serum to avoid the errors suggested by the previous experiments.

The action of the "immune" serum in each case was compared with that of two samples of serum drawn from the same animal before the injections were made, and the comparison was made in parallel series of increasing amounts of serum, the same solution of trypsin being employed and the experiments being carried out at the same time. In no case was any increased action observed to follow the injections.

The injections, however, caused the production of a precipitin, which must therefore be attributed to the presence of protein accompanying the enzyme and not to the enzyme itself. These experiments, therefore, bring forward some evidence that trypsin is not a protein.

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AUSTRALIAN *TABANIDÆ* [DIPTERA]. No.iv.*

By Frank H. Taylor, F.E.S.

(*From the Australian Institute of Tropical Medicine, Townsville.*)

(Plates i.-ii.)

The Tabanidæ comprising most of the subject-matter of this paper have been received from Mr. Longman, Director of the Queensland Museum, and Messrs. W. W. Froggatt, R. J. Tillyard, and G. F. Hill. I wish to tender my best thanks to these gentlemen for affording me the opportunity of studying these forms.

Mr. Hill's collection contained by far the greater number of novelties, but the most distinctive and beautiful *Tabanus* yet described, *T. walteri*, was contained in Mr. Froggatt's collection, the type of which he has generously presented to the Institute. The Institute is also indebted to Mr. Hill's generosity in giving the types of his new species.

One new genus has been proposed for a striking species of the subfamily Tabaninæ, and descriptions of twenty-six new species and one variety are given, which are distributed in the following genera —*Silvius* (three, and one variety), *Cydistomyia* (g. et sp.n.), and *Tabanus* (twenty-two).

Subfamily PANGONINÆ.

PELECORHYNCHUS FULVUS Ricardo.

Ann. Mag. Nat. Hist., (8)., v., p.406 (1910).

Hab.—N.S.W.: Mount Bindo, 4,100 feet, near Hampton (R. J. Tillyard).

PELECORHYNCHUS NIGRIPENNIS Ricardo.

Ann. Mag. Nat. Hist., (8), v., p.405 (1910).

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* Continued from Vol. xlii., 1917, p.528.

My reference to *P. maculipennis* Macq., (Proc. Linn. Soc. N. S. Wales, 1917, xlii., pp.513 and 515), should refer to *P. nigripennis* Ricardo.

EREPHOPSIS LASIOPHTHALMA Boisd.

Voy. "Astrolabe," Zool., ii., p.666 (1832); Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.210 (1917); Taylor, Records Aust. Mus., xii., No.5, p.56 (1918).

A specimen in Mr. Froggatt's collection agrees with Miss Ricardo's description in all details except the antennæ, which are black, and the palpi black, with the apical third of the second joint dark red, pubescence mainly black.

Hab.—W.A.: Darlington (J. Clarke; Coll. W. W. Froggatt, No.83F).

EREPHOPSIS SUBMACULA Walker.

List. Dipt., i., p.142 (1848); *id.*, Dipt. Saund., i., p.13 (1850); Ricardo, Ann. Mag. Nat. Hist., (7), v, p.115 (1900).

A specimen under review agrees with Miss Ricardo's description. The third joint of the antennæ is broken. The wings are yellowish along the costa, and at the base, and have the first and fourth posterior cells closed for a short distance from the border.

Miss Ricardo remarks that this species should belong to *Scione* Walker, (*Diclisa* Schiner), but that it is too nearly allied to *E. guttata* Don., and *E. media* Walker, to make it advisable to remove it from *Erephopsis* at present.

Hab.—W. Australia (C. French, 1909; Coll. W. W. Froggatt, No.84F).

DIATOMINEURA BREVIROSTRIS Macquart.

Dipt. Exot., Suppl., iv., p.326 (1842); Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.208 (1917).

Hab.—Q.: Mt. Tambourine (W. H. Davidson, *per* R. J. Tillyard).

DIATOMINEURA AURIFLUA Donovan.

Gen. Illustr. Ent. Hym. et Dipt. (1805) [*Tabanus*]; Ricardo, Ann. Mag. Nat. Hist., (8), xix., p.208 (1917).

Hab.—Tasmania: Launceston (F. M. Littler).—N.S.W.: Hampton (R. J. Tillyard).

Diatomineura ianthina White.

Pap. and Proc. Roy. Soc. Tasmania, 1915, p 19.

Hab.—Tasmania (F. M. Littler).—N.S.W.: Hampton (R. J. Tillyard).

Silvius notatus Ricardo.

Ann. Mag. Nat. Hist., (8), xvi., p.264 (1915).

A specimen sent by Mr. Froggatt agrees with this species in all details except as regards the clothing of the front, which is a dark brown colour, yellowish between the sub- and frontal calli, frontal callus shining black, about two-thirds the width of the front, upper edge oval, no lineal extension, its base a short distance from the subcallus, the latter with a shallow median groove; ocelli prominent, with grey tomentum round them as in the type.

The third joint of the antennæ and the palpi are broken off.

A second specimen also appears to represent this species, but both the thorax and the abdomen are somewhat denuded; there is scarcely any trace of spots on the abdomen, and the stripes on the thorax are indistinct, otherwise it is typical.

Hab.—N.S.W.: Hay, Moree (W. W. Froggatt, Nos.72, 74F).

The specimen from Hay was taken on the trunks of red-gums (*Eucalyptus* sp.) on the banks of the Murrumbidgee River; the one from Moree was taken by sweeping grass on marsh-land.

Silvius elongatulus Taylor.

Proc. Linn. Soc. N. S. Wales, 1915, xl., p.812 (1916).

S. elongatulus, var. persimilis, var. nov.

♀. Similar in all details to the typical form, except the legs and abdomen.

Legs black; basal third of fore-tibiæ yellowish-brown, tibiæ and tarsi of midlegs yellowish-brown, tibiæ and tarsi of hindlegs dusky brown, first tarsals paler.

Abdomen: first three segments honey-yellow (one specimen has the first four segments honey-yellow), fourth brownish, the remainder grey-black, pubescence pale, segmentations pale.

Hab.—N. Territory: Brock's Creek, Batchelor, and Darwin (G. F. Hill).

There is a striking similarity between *S. elongatulus* and the specimens described as var. *persimilis*, so much so that the above distinctions do not appear to warrant their separation as distinct species I omitted to state, in describing *S. elongatulus*, that the front is nearly twice the width anteriorly than posteriorly.

Silvius angusticallosus, sp.n.

♀. Length, 9·5; width of head, 3; length of wing, 10 mm.

A small, slender, black and yellowish species. Frontal callus a narrow line reaching the ocelli; legs black, tibiæ yellowish; wings yellowish-brown, basal cells clear. Abdomen with first three segments yellowish-brown, darker in the middle. Eyes pubescent.

Head: face and cheeks with blackish tomentum, grey toward sides of cheeks; pubescence black, interfacial cheek-grooves deep; beard black and grey, scanty; eyes with scanty pubescence; front narrow, slightly narrower at the vertex; tomentum grey, yellowish-brown in the centre; pubescence dark; frontal callus black, consisting of a narrow line from the subcallus to the ocelli; subcallus black, tomentum grey; palpi as long as proboscis, reddish, tomentum grey, pubescence black, pale at base; first two joints of antennæ yellowish, pubescence pale, third joint reddish-yellow, the three apical annuli blackish.

Thorax chocolate-brown with grey tomentum [somewhat denuded], pubescence pale; scutellum similar; pleuræ black, tomentum and pubescence grey.

Abdomen: first three segments pale yellowish-brown on the sides, less so on first segment, blackish-brown elsewhere, the remaining segments black, segmentations pale on all segments, with pale pubescence, black elsewhere; venter pale, blackish towards apex, pubescence pale.

Legs black, basal half of fore- and midtibiæ yellowish-brown, hind darker, coxal pubescence pale, black elsewhere.

Wings yellowish-brown, darker on fore-border; except the discal, inferior basal, anal, axillary, and bases of the fourth and fifth posterior cells, which are clear, the veins of these cells are faintly clouded, the veins blackish-brown; stigma blackish-brown no appendix.

Hab. Q.: Stradbroke Island (H. Hacker).

A very distinct species on account of the frontal callus alone. t is most nearly related to *S. niger* Ricardo, but is markedly istinct.

Type in the Queensland Museum.

SILVIUS HACKERI, sp.n.

♀. Length, 15·5; width of head, 5·5; length of wing, 13; prooscis, 4 mm.

A large, blackish brown species; antennæ and palpi brownish; gs reddish brown; abdomen with median grey, apical flecks, egmentations grey.

Head: face and cheeks black, tomentum grey, pubescence ainly black; grooves between face and cheeks deep; subcallus hining chestnut-brown; front broad, parallel, tomentum dull olden, tinged with brown, brighter anteriorly, pubescence lack; frontal callus kite-shaped, constricted near the base of iddle third, dull reddish-brown, about half the width of front t widest part; first two joints of antennæ dark reddish-brown, hird black, base broad, concave laterally, pubescence black, canty; palpi conspicuously long, second joint greyish-black, pex black, truncate, base concave laterally; proboscis long, lack; beard grey: eyes bare.

Thorax chocolate-brown, with three brownish stripes, the edian one broad and half the length of thorax; tomentum grey; houlders pale reddish, pubescence black, long laterally, with grey airs beneath; scutellum dark reddish-brown, posterior pubesence grey; pleuræ pale reddish-brown, tomentum and pubescence rey.

Abdomen blackish-brown; second segment reddish-brown, grey n profile, segmentations grey, median grey-haired, apical, tringular flecks on the first six segments, lateral borders of segents pale with pale hairs, more pronounced posteriorly; venter ale on the sides, black in the middle, tomentum grey, pubescence rey and black.

Legs reddish-brown, tarsi darker, pubescence black, grey on oxæ.

Wings clear; veins dark brown; stigma brown; no appendix.

Hab.—Q.: Brisbane (H. Hacker).

Allied to *S. grandis* Ricardo, from N.W. Australia, but distinguished from it by the frontal callus, thorax, abdomen, legs, and wings.

Type in the Queensland Museum.

SILVIUS VICINUS, sp.n.

♀. Length, 11; width of head, 4; length of wing, 10 mm.

A small species with yellowish thorax and brown abdomen, with traces of median spots. Femora reddish-yellow, tibiæ and tarsi black. Wings clear, appendix rudimentary.

Head: face and cheeks covered with grey tomentum and scanty grey pubescence; beard grey, scanty; first two joints of antennæ reddish-yellow, pubescence black; third joint darker; apex dark brown, base broad; palpi pale yellowish-red, tapering to a blunt point, pubescence pale at base, scanty; front about twice as wide at vertex, tomentum golden, pubescence black, frontal callus wedge-shaped, brownish-yellow, about one-third the width of the front, lineal extension reaching the ocellar triangle; ocelli prominent; subcallus paler than front; eyes bare.

Thorax with dense golden-yellow tomentum, pubescence pale yellow and black, the latter very scattered, grey on the sides; scutellum similar to thorax; pleuræ slate-coloured, pubescence grey, dense at the wing-roots.

Abdomen: first two segments yellowish-brown, the rest blackish-brown, segmentations pale, pubescence black, pale on segmentations; there are indefinite, yellow-haired, median, apical, triangular spots on the segments.

Legs: coxæ and femora reddish-yellow, with pale pubescence; tibiæ and tarsi black, the former pale at the base, pubescence black.

Wings clear; veins dark brown; stigma yellowish-brown; appendix rudimentary on one wing, absent on the other.

Hab.—Q: Stradbroke Island (H. Hacker).

Related to *S. fulvohirtus* Taylor, but separated from it, *inter alia*, by its abdomen and legs.

Type in the Queensland Museum.

Subfamily TABANINÆ.

CYDISTOMYIA, gen.nov.

Face protuberant, with sublateral grooves; antennæ rising from vell-defined cavities, third joint with six divisions, last division ery obscure; first segment fairly long, cylindrical, second about ne-third the length of the first, base of third as in *Tabanus*, ong. Palpi about two-thirds the length of the proboscis, with irst joint short and swollen, second as in *Tabanus*; eyes nude; vings about twice the length of abdomen, radial vein slightly urved, all cells widely open except the anal, which is closed near he border. Abdomen short and comparatively broad, as long s the thorax.

Genotype, *C. doddi* Taylor; ♂ unknown.

This genus is proposed for a species having a general resemlance to a Pangonid. It is abundantly distinct from all species lescribed from Australia known to me.

CYDISTOMYIA DODDI, sp.n.

♀. Length, 12; length of wings, 11; width of head, 5 mm.

Head: face and cheeks grey, faintly tinged with cream, lower half of face between the grooves brown; pubescence pale, face slightly protuberant; grooves between face and cheeks not continuous, terminating about one-third the depth of the face from the bottom; beard scanty, pale cream-coloured; first and second joints of antennæ black, pubescence black, long on the ventral surface, base of third blackish-brown, with dense, short, black and grey pubescence, annuli black, base with a small tooth; palpi black, pubescence black, second joint tapering to a fine point; front narrow, sides parallel, covered with yellowish-brown tomentum, with a narrow border of pale pubescence from the base to the apex of the extension of the frontal callus, the latter spear-shaped, shining brown, about two-thirds the width of the front at the base, not quite resting on the subcallus, the lineal extension reaching the middle of the front; subcallus grey, very slightly tinged with cream.

Thorax: anterior half olive-brown, with two sublateral olive stripes reaching the posterior third, posterior half deep olive-brown, sides and posterior border broadly golden, also a short, pale band from the sides joining the olive stripes at the apex of the anterior third, pubescence golden on the golden areas, elsewhere black; pleuræ covered with grey tomentum and pubescence, the latter golden beneath the shoulders.

Abdomen deep olive-brown; all the segments with creamy-white, apical, triangular flecks, segmentations narrowly pale, sides of segments with apical, more or less triangular flecks diminishing in size towards the apex of the abdomen; pubescence pale on the creamy areas, black elsewhere; venter entirely greyish with pale pubescence.

Legs blackish-brown, pubescence black.

Wings very faintly tinged brown: veins black, the radial vein slightly curved; stigma yellowish; no appendix.

Hab.—Q.: Kuranda (F. P. Dodd).

Described from a single specimen. It is a very distinct and beautiful insect, and is named in honour of its discoverer.

Group iv. Forehead with no callus.

TABANUS ANGUSTICALLUS Ricardo.

Ann. Mag. Nat. Hist., (8), xix., p.218 (1917).

A single specimen before me shows that the thorax has numerous pale hairs in addition to the black pubescence. The annuli of the third joint of the antennæ are brownish when viewed from above.

Hab.—N. Territory: Howard Creek (G. F. Hill).

Group vii. Abdomen with one or more stripes, usually continuous.

TABANUS WALTERI, sp.n.

(Plate i., fig.1).

♀. Length, 15·5; length of wing, 14; width of head, 5·5 mm.

Head: face with grey tomentum and pubescence, darker on the cheeks; subcallus with brown tomentum; front grey, with grey pubescence, somewhat darker in the centre, very slightly narrower at the base, frontal callus almost square with a lineal extension reaching the centre, upper portion and extension eddish-brown, the rest reddish-yellow; beard grey, scanty; palpi pale reddish-yellow tapering to a fine point, pubescence black; irst and second joints of antennæ dark red, apex of first black, pubescence black, with scattered pale hairs, third joint black, vith a small tooth on the expanded basal portion.

Thorax grey, with a narrow, whitish, median line reaching the cutellum; a dark brown, fairly broad stripe on the sides, in vhich is a narrow, grey stripe from the suture to near the poserior extremity of the brown stripe, a narrow, grey stripe from he wing-roots to the scutellum, shoulders, and sides to the wingroots reddish; scutellum red, with a dark blotch anteriorly, omentum grey, pubescence of thorax and scutellum dark; pleuræ with grey tomentum and pubescence.

Abdomen reddish-brown, becoming almost black on the last wo segments, segmentations and sides of all segments grey; all he segments with median, trapezium-shaped, grey patches, which are wider at the apex than at the base, pubescence grey on the stripe, segmentations, and sides, dark elsewhere; venter grey, with a broad, median, dark stripe.

Legs: coxæ and femora slate-grey, with grey pubescence, basal half of the fore- and mid-tibæ and knees yellowish-brown, hindibiæ yellowish, apex of mid-tibiæ blackish, pubescence grey, arsi blackish, pubescence black.

Wings with prominent, grey patches in all cells; veins black, stigma yellowish-brown; appendix on right wing very short, rudimentary on the left.

Hab.—N.S.W.: Hay (W. W. Froggatt, No 71F.; 20-12-17).

This is one of the most distinct and handsome Australian species of *Tabanus*. The thoracic ornamentation, and the shape of the abdominal spots are very marked.

It affords me very great pleasure to dedicate this species to its discoverer.

TABANUS EIDSVOLDENSIS, sp.n.

(Plate ii., fig.2)

♀. Length, 10·5-14; width of head, 4-5; length of wing, 9·5-11mm.

Head: face and cheeks black, with grey tomentum and pubescence; subcallus reddish-brown, tomentum grey; front parallel, tomentum grey, brownish round the apical extremity of the frontal callus, pubescence black, fairly long on vertex, frontal callus dark reddish-brown, resting on subcallus, as wide as front, almost square with a stout lineal extension reaching beyond the centre of front; palpi pale reddish-yellow, ending in a blunt point, pubescence black, with numerous, fairly long, pale hairs on basal portion; antennæ reddish-yellow, darker than palpi, annuli appearing dusky, pubescence on first two joints black, with a few pale hairs beneath, base of third broad, no angle or tooth; beard grey.

Thorax black, sides reddish, tomentum grey, with three chocolate-brown stripes, pubescence black, with intermixed grey hairs especially noticeable on the posterior half, mainly black laterally and fairly long; scutellum black, with mixed black and pale pubescence; pleuræ black, reddish beneath wing-roots, tomentum and pubescence grey.

Abdomen: first segment dusky, next three reddish-brown, remainder darker, segmentations grey, fairly broad on first four segments, with median, grey, triangular spots forming a continuous stripe on segments two to six, pubescence black, pale on posterior borders; venter reddish-yellow, apex darker, pubescence pale.

Legs: coxæ and forelegs black, coxæ and femora with grey tomentum and long grey pubescence, black elsewhere, very dense on tarsi, basal two-thirds of fore-tibiæ dark yellowish-brown, with a few pale hairs; mid- and hindlegs yellowish-brown, femora dusky, tomentum grey.

Wings clear; veins brown; stigma yellow; a short appendix present.

Hab.—Q.: Eidsvold (Dr. T. L. Bancroft).

This species appears to be most nearly related to *T. laticallosu* Ricardo, but is readily differentiated from it. It bears a superficial resemblance to *T. circumdatus* Walker, of Group xi.

TABANUS OBSCURILINEATUS, sp.n.

(Plate i., fig.3).

♀. Length, 11·5; width of head, 4·5; length of wing, 10 mm.

Head: face and cheeks with grey tomentum and white pubes ence ; subcallus pale chamois, with a median furrow ; front bout one-third narrower anteriorly, darker than subcallus, ubescence pale, frontal callus brown, small, oblong, no lineal xtension, about one-third of the width of front, and not quite esting on subcallus; palpi creamy, first joint with long, grey ubescence, second swollen, ending in a blunt point, pubescence lack and pale, mainly the former; first two joints of antennæ nd base of third reddish-yellow, annuli darker, tooth represented by a large, shallow angle, pubescence black on first two oints; eyes black.

Thorax covered with brown tomentum, and black and coppery ubescence, shoulders pale reddish, with long, dark pubescence, cutellum similar; pleuræ grey, with grey pubescence.

Abdomen honey-yellow, the first four segments with black, riangular, median patches, their bases resting on the posterior margin of segments, except in the first segment, stripe covered with brown tomentum, in the remaining segments the median patches do not reach the posterior margin, pubescence black; enter reddish-yellow changing to black posteriorly, with brown omentum, pubescence pale.

Legs black, basal half of fore-tibiæ yellowish, with pale pubescence, mid- and hind-tibiæ and apex of femora yellowish, coxæ and femora with grey tomentum and pubescence, hind-tibiæ with black and pale pubescence, black elsewhere.

Wings clear; veins yellowish-brown; stigma yellow; no appendix present.

Hab.—N. Territory : Darwin (G. F. Hill).

Described from two specimens, which bear a certain relationship to *T. reducens* Walker, from Macassar and Celebes, and to *T. queenslandii* Ricardo, but are abundantly distinct from them. The specimens bear the following note—"In house, daytime. Eyes green."

Paratype in Coll. Hill.

TABANUS OBSCURIMACULATUS, sp.n.

(Plate ii., fig.4).

♀. Length, 13-17; width of head, 4-5·5; length of wings, 11-14·5 mm.

Head: face, cheeks, subcallus, and front chamois-coloured, pubescence on face and cheeks white, scanty; beard grey; front slightly narrower anteriorly, pubescence black, with a tuft of pale and black hairs on the vertex, frontal callus reddish-brown, pear-shaped, with a long, linear extension, about two-thirds the length of the front; palpi pale creamy, second joint swollen, tapering to a fine point, pubescence pale, with a few, short, scattered, black hairs; first two joints of antennæ pale reddish-yellow, with greyish tomentum and black pubescence, third joint darker, annuli dusky, expanded portion with a very small tooth.

Thorax black, shoulders yellowish-red, tomentum grey, pubescence black and pale, fairly long on the sides, scutellum similar to thorax; pleuræ with grey tomentum and pubescence.

Abdomen: first three segments honey-yellow, the remainder black, second and third with an obscure black spot, somewhat variable in size, tomentum grey, pubescence black and pale venter pale reddish-yellow, darker towards apex, with dense grey pubescence, lateral margins with pale pubescence except at the apex.

Legs reddish-yellow, tarsi darker, pubescence pale on coxæ and femora, black and pale on tibiæ, and black on tarsi.

Wings clear; veins yellowish-brown; stigma yellow; no appendix present.

Hab.—N. Territory: Darwin (G. F. Hill, No. 105).

A medium-sized species, more or less closely related to *T. obscurilineatus* mihi, and *T. queenslandii* Ricardo.

Paratype in Coll. Hill.

TABANUS QUADRATUS, sp.n.

♀. Length, 9-10·5; width of head, 3-3·5; length of wing, 8-9mm

Head: face with yellowish tomentum, slightly protuberant grooves well developed; cheeks grey, tomentum and pubescenc grey; beard grey, scanty; subcallus yellowish, with dull golde tomentum; front black, broad, with dark pubescence, giving it dusky appearance, and a few pale hairs on the sides, paralle about twice as long as broad, frontal callus dark red-brow square, about half as wide as the front, and resting on the sub callus; first two joints of antennæ yellowish, with scanty black pubescence, base of third reddish-yellow, annuli darker, tooth represented by a shallow angle; palpi yellow, tomentum and pubescence grey, the latter mainly black on second joint.

Thorax black, with grey tomentum, pubescence black and pale, shoulders reddish, with fairly long, dark pubescence, scutellum similar to thorax; pleuræ black, with grey tomentum and pubescence.

Abdomen: first three segments tawny, the remainder dark brown, fourth segment paler, segments two and three with obscure, median, black spots, all the segments with indications of a continuous pale stripe, pubescence black, with scattered pale hairs, posterior and lateral borders with pale pubescence, sides of last three segments yellowish; venter pale reddish-yellow, the three apical segments dusky, pubescence mostly pale.

Legs yellowish, apex of fore-tibiæ and all the tarsi darker, pubescence pale on coxæ, and mid- and hind-femora black elsewhere.

Wings grey; veins brown, paler basally; stigma yellow; an appendix present.

Hab.—N. Territory: Darwin (G. F. Hill; Nov. 1913).

Described from two specimens, one of which is slightly damaged, and with a dirty wing. Close to *T. similis* Macq., from Tasmania, but distinguished by the abdomen in the latter species being warm buff, and having a broad, median, mummy-brown stripe, with a narrow, grey, tomentose stripe on it. Mr. Hill notes that the eyes are bright green in life.

TABANUS AUSTRALICUS, sp.n.

♀. Length, 13; width of head, 4·5; length of wing, 10·75 mm.

A blackish-brown species. Thorax slate-coloured. Abdomen blackish-brown, first two segments yellowish. Legs black, tibiæ yellowish. Wings grey.

Head: face and cheeks with grey tomentum and pubescence; beard grey, scanty; first joint of antennæ reddish-yellow, apex black above, second segment black, very short, almost obscured by the first when viewed from above, pubescence black on both segments, third joint black, base with an obtuse angle, no tooth present; palpi pale reddish-yellow, very stout, ending in a blunt point, pubescence grey and black, mainly the former; front parallel, tomentum grey, brownish in the centre, pubescence black and creamy; frontal callus reddish-brown, almost circular, about one-third of the width of front, and not quite resting on the subcallus, which is creamy; lineal extension black, long.

Thorax slate-coloured, pubescence golden, shoulders pale reddish; scutellum similar to thorax, pubescence pale, long on posterior border; pleuræ black, tomentum and pubescence grey.

Abdomen: first two segments and basal half of third brownish, first segment darker; the remainder blackish-brown, segmentations pale, a continuous, grey tomentose-stripe on segments one to six, pubescence black, grey on the stripe, sides of segments, and bands; venter slate-coloured, segmentations and pubescence pale.

Legs black, coxæ and femora with grey tomentum and pubescence, basal half of fore-, basal two-thirds of mid-, and the whole of hind-tibiæ reddish-yellow, the rest of legs black, pubescence pale on tibiæ, black on tarsi.

Wings grey; veins blackish-brown; stigma yellowish; no appendix.

Hab.—Q.: Brisbane (H. Hacker).

A species most nearly related to *T. queenslandii* Ricardo, but differing chiefly in the thorax, abdomen, and legs.

Type in Queensland Museum.

TABANUS DAPHŒNUS, sp.n.

♀. Length, 10-11·5; width of head, 3·5-4·5; length of wing 8-9·5 mm.

Head: face and cheeks with grey tomentum and pubescence subcallus darker, yellowish at base of antennæ; front parallel narrow, tomentum dull golden, grey on vertex, pubescence black densest on vertex, frontal callus about half the width of front lenticular, brownish-yellow, with a median groove, lineal extension black, reaching middle of front; first two joints of antennæ golden, second joint obscured by first from above, pubescence black, base of third dull reddish-yellow, with a blunt tooth, annuli dusky; palpi creamy-yellow, second joint stout at base, pubescence black and pale; beard grey.

Thorax black, shoulders reddish, tomentum slate-grey, pubescence black and pale, fairly long on the sides, scutellum similar; pleuræ with grey tomentum and pubescence.

Abdomen: first three segments reddish, the remaining segments darker, pubescence mixed pale and black; all the segments show an indistinct, pale median stripe when viewed from behind forwards; one specimen has the first two reddish, and the remaining segments dusky; venter reddish, darker towards apex.

Legs: forelegs black, except basal half of tibiæ reddish-yellow, with pale pubescence; mid- and hind-femora with the basal half faintly dusky, and with grey tomentum, the rest of femora and the tibia reddish-yellow, with pale pubescence, tarsi dusky, with black pubescence.

Wings clear, subcostal, first long vein, and veins on basal half yellowish, the rest brown; stigma yellowish; no appendix.

Hab.—N. Territory: Darwin, and thirty miles east of Darwin (G. F. Hill, Nos.111, 113).

A well-defined species, and, apparently, not closely related to other members of Group vii. Mr. Hill notes that the eyes are greenish-bronze, and that it is a persistent biter of horses.

Paratype in Coll. Hill.

Group viii. Species with median or lateral spots, or both, on abdomen, not usually forming a continuous stripe.

TABANUS GRISEUS, n.sp.

♀ Length, 11·5; length of wing, 10; width of head, 4 mm.

Head: face and cheeks with grey tomentum and pubescence, face slightly convex in the middle, with a shallow groove on either side, pubescence and tomentum grey, yellowish beneath subcallus, with black pubescence, subcallus with pale golden-yellow tomentum; front converging slightly towards vertex, tomentum golden, pubescence black, frontal callus shining black, bottle-shaped, with a short, thick extension; beard grey, scanty; first two joints of antennæ golden, with short, black pubescence, third joint pale reddish-yellow, annuli darker, basal portion with an inconspicuous angle; palpi yellow, ending in a blunt point pubescence short, mixed pale and black.

Thorax deep greyish-olive, pubescence dark, scanty, scutellun similar; pleuræ with grey pubescence and tomentum.

Abdomen deep greyish-olive, pubescence black, short, segmentations with scanty pale pubescence; segments three to five with pale, median, apical, triangular spots when viewed from the heac toward the abdomen; sides of segments yellowish; venter black with grey tomentum and pubescence.

Legs black, apices of femora yellowish-brown, apical third o fore-tibiæ blackish, the remainder with mid- and hind-tibia yellowish-brown, tarsi black; pubescence on femora and tibia mainly pale, black on tarsi; coxæ grey, with grey pubescence.

Wings: upper half lightly shaded with pale brown, vein black, faintly clouded with brown, except the anal vein anc those forming the posterior cells; stigma dark yellowish-brown appendix present.

Hab.—Q.: Brisbane (H. Hacker; 20.12.17).

Type in the Queensland Museum.

This species does not seem to be closely related to any othe member of Group viii. It appears to be a very distinct species

TABANUS APREPES, sp.n.

♀. Length, 13·5; width of head, 5; length of wing, 11·5 mm.

Head: face, cheeks, and subcallus grey, pubescence on fac and cheeks grey; front parallel, with grey tomentum, creamy o the sides, pubescence black, with scattered yellow hairs, chiefl on the sides, frontal callus black, pear-shaped, half the widt of front and resting on subcallus, with a long extensio reaching the middle of the front; palpi white, with black an white pubescence, stout, ending in a blunt joint; first two joint of antennæ yellowish, pubescence black above, grey laterally third black, tooth represented by a broad angle; beard grey scanty.

Thorax slate-grey, pubescence golden, sides reddish, pubescen lack, scutellum similar to thorax; pleuræ with grey tomentum nd pubescence.

Abdomen pale yellowish-red, pubescence black, all segments ith a small, median, apical, triangular, pale fleck; pubescence ale laterally; venter yellowish-red, pubescence pale.

Legs: forelegs and basal two-thirds of mid- and hind-femora lack, basal two-thirds of tibiæ and knees yellowish-brown, with ale pubescence, apical third of mid- and hind-femora, and the ibiæ and tarsi paler than fore-tibiæ, coxæ and femora with grey omentum and pubescence, the latter mixed pale and black on emora, very dense on tarsi.

Wings clear, grey; veins dark brown; stigma yellow; no apendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Described from a single specimen, and apparently closer to *T. innotabilis* Walker, than to other members of Group viii.

Group ix. Species with paler bands, and sometimes spots on the abdomen.

TABANUS BREVIOR Walker.

List. Dipt., i., p.188 (1848); Ricardo, Ann. Mag. Nat. Hist., 8), xv., p.279 (1915).

Hab.—N. Territory: Darwin, Howard Creek (G. F. Hill, No.110).

The specimens before me do not agree well with Miss Ricardo's escription of this species; but, until a specimen has been compared with the type, it is deemed advisable to leave them under he above name.

TABANUS MACQUARTI Ricardo.

Ann. Mag. Nat. Hist., (8), xiv., p.277 (1915).

Hab.—N.S.W.: Kendall (R. J. Tillyard).—Q.: Mt. Tambourine W. H. Davidson *per* R. J. Tillyard).

TABANUS SEQUENS Walker.

List. Dipt., i., p.178 (1848); Ricardo, Ann. Mag. Nat. Hist., (8), xv., p.278 (1915).

Hab.—N. Territory: Darwin (G. F. Hill, No. 106).

TABANUS KURANDÆ, sp.n.

(Plate i., fig.5).

♀. Length, 17·5; width of head, 6·5; length of wing, 15 mm.

Head: face and cheeks black, with grey tomentum and black pubescence, lower third of face yellowish; beard grey, scanty; subcallus black, tomentum dull golden; front black, parallel, narrow, tomentum dull golden, pubescence black, frontal callus scarcely as wide as front, resting on subcallus, bottle-shaped, black, tumid, lineal extension thin, reaching the middle of front; palpi large, swollen, yellow, with dense black pubescence and a few pale hairs at the base, almost as long as proboscis, and ending in a blunt point; antennæ red, first joint long, about thrice the length of second, pubescence black, annuli dusky, tooth represented by a broad angle.

Thorax shining black, tomentum a dirty yellowish-brown, pubescence black, very short, sides red, with black pubescence, fairly long; scutellum red, base black, tomentum as on thorax, pubescence pale on posterior border; pleuræ with grey tomentum and pubescence.

Abdomen: segments one to four black, second to fourth with broad red segmentations, first with grey tomentum and a median tuft of yellowish hairs, segmentations pale, five to the apex red, pubescence black; venter with dark tomentum, pubescence black, segmentations pale.

Legs: femora and first tarsals dull red, tibiæ yellowish, apices reddish, pubescence black, dense on tarsi, tibiæ with pale hairs in addition.

Wings clear; veins brown; stigma pale yellow; no appendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Type unique. Very distinct and readily distinguishable on account of its abdominal ornamentations.

TABANUS BATCHELORI, sp.n.

(Plate ii., fig.6).

♀. Length, 13·5; width of head, 5; length of wing, 11 mm.

Head: face and cheeks covered with grey tomentum an pubescence, the latter fairly dense on the face, beard white; front parallel, tomentum grey-brown, pubescence black and golden, frontal callus brownish-black, small, about half the width of the front, pear-shaped, with a short lineal extension and resting on the subcallus, the latter with grey tomentum; eyes black; palpi creamy, with black and white pubescence, second joint swollen and tapering to a blunt point; first two joints and base of third of antennæ yellowish-brown, pubescence black and white on the first two joints, the remainder of third joint black, with a prominent angle and tooth.

Thorax black, shoulders reddish, pubescence black and copper-coloured; scutellum similar; pleuræ black, tomentum and pubescence grey, the latter long.

Abdomen yellowish-brown, becoming darker toward the apex, first two segments with small, black, median spots, pubescence black, dense, with indistinct, median, grey spots on all but the first segment; venter grey, with dense grey pubescence.

Legs black, basal half of fore-tibiæ yellowish, with pale pubescence, apex of femora and the tibiæ of mid- and hindlegs yellowish, with black and pale pubescence, tarsi dusky, pubescence black, coxæ and femora with grey tomentum and pubescence, the latter long on the coxæ.

Wings grey, brownish below the stigma, the base of the anterior branch of the third long vein, apex of the discoidal, the apex and basal portion of the inferior basal cells shaded brown; stigma dirty yellow; veins black; no appendix present.

Hab.—N. Territory: Batchelor, and near Darwin (G. F. Hill).

A species related to *T. sequens* Walker, but abundantly distinct from it.

Paratype in Coll. Hill.

TABANUS ATMOPHORUS, sp.n.

(Plate i., fig.7).

♀. Length, 10; width of head, 4; length of wing, 9 mm.

Head: face grey, with grey tomentum; cheeks ash-coloured, pubescence grey; subcallus black, tomentum ash-coloured; front black, tomentum ash-coloured, paler on the sides, pubescence black, narrow, parallel, frontal callus square, reaching the eyes, black, with a stout lineal extension with a well marked groove, and reaching the apex of the middle third; palpi black, ending in a fine point, pubescence mostly grey; first joint of antennæ black, second and expanded portion of the third red, annuli black, pubescence on first and second joints black; beard grey.

Thorax black, red above the wing-roots, tomentum grey, pubescence black, lateral pubescence black, fairly long, scutellum similar to thorax; pleuræ with grey tomentum and pubescence.

Abdomen black, with black pubescence, first segment with grey tomentum, two to five grey on the sides, segmentations brown, with grey-white pubescence and tomentum, pubescence black on the last two segmentations, lateral pubescence grey-white; first two segments of venter grey, with grey pubescence, the remainder as on dorsum.

Legs black, knees orange-yellow, pubescence black.

Wings clear; veins dark brown; stigma yellowish-brown; no appendix present.

Hab.—Q.: Kuranda (F. P. Dodd).

Very close to *T. griseoannulatus* Taylor, but distinguished from it by the different frontal callus, colour of cheeks, and the knees. This species is also less robust in build.

TABANUS CRYPSERYTHRUS, sp.n.

Length, ♂, 10·5; ♀, 9-10·5: width of head, ♂, 4; ♀, 3-4 (vix): length of wing, ♂, 9; ♀, 8·5-9 5 mm.

♂. *Head:* face sunken, covered with whitish tomentum and pubescence; cheeks with grey tomentum and pubescence; subcallus grey, with a median groove, apical portion with grey-brown tomentum; palpi pale yellowish, first joint about half as stout as second, the latter nearly uniform in width, and tapering to a blunt point, pubescence grey, with a few scattered dark hairs on the apex; first two joints of antennæ slender, yellowish, with black pubescence, third reddish-yellow, tooth represented by a broad angle, with some black pubescence on the apex, annuli dusky-brown; eyes composed of fairly large, brown facets, the lower fourth and a narrow band encircling the eyes composed of very small, black facets; beard grey, scanty.

Thorax black, with dull golden tomentum and dark, erect pubescence, sides with mainly pale pubescence, scutellum similar; pleuræ black, with grey tomentum and pubescence, with some yellowish-hairs below the wing-roots.

Abdomen: first two segments yellowish-brown, third and fourth reddish-brown, the fourth darker than third, the rest blackish, their sides pale reddish-yellow, segmentations pale, pubescence black; first three segments of venter pale reddish-yellow, fourth dark red-brown, remainder blackish with pale segmentations, pubescence pale.

Legs: forelegs black, basal two-thirds of tibiæ dusky-red, mid- and hind-femora black, tibiæ yellow, apices tinged with reddish, first tarsals with basal half tinged reddish, the rest dusky, pubescence black, mixed with pale hairs on the coxæ and femora, tomentum on coxæ and femora grey.

Wings clear; veins brown, those on the basal half of wings and the subcostal yellow; stigma pale yellowish-brown; no appendix present.

♀. *Head:* face and cheeks as in ♂, but face *not* sunken; subcallus with grey tomentum; front parallel, narrow, with grey tomentum and black pubescence, frontal callus dark reddish-brown almost reaching the eyes, pear-shaped, with a moderately stout, blackish, lineal extension reaching the middle of the front; palpi pale yellowish, with mixed black and pale pubescence. There is a small, indefinite, black spot in the centre of the second segment of the abdomen, which is almost absent in ♂.

Hab.—N. Territory: Darwin, Stapleton, and 34-Mile Railway Station (G. F. Hill, No. 8).

Apparently, a well-defined species, most nearly related to *T. nigrimanus* Walker, but readily differentiated from it, *inter alia*, by the legs and antennæ.

TABANUS FUGITIVUS, sp.n.

♀. Length, 13; width of head, 5; length of wing, 12 mm.

Head: face and cheeks covered with grey tomentum, pubescence grey, lower portion of face yellowish; beard grey, front black, tomentum a dirty-grey, frontal callus black, pear-shaped, no lineal extension, resting on the subcallus, and about one-third of the width of the front; subcallus black, tomentum grey; palpi yellowish, pubescence pale, apical third of second joint uniform in width, and ending in a blunt point; first two joints of antennæ reddish-brown, pubescence black, basal portion of third darker than first two, annuli black.

Thorax black, tomentum brown, greyish anteriorly, pubescence black, scutellum similar; pleuræ with grey tomentum and scattered grey pubescence.

Abdomen: second segment yellowish-brown, the remaining segments brown, the apical four black when abraded, pubescence black; all segments with indistinct, apical, median, grey spots, segmentations yellowish; venter black, with greyish tomentum and pale pubescence, segmentations pale.

Legs black, femora and coxæ with grey tomentum and pubescence, long on coxæ, knees pale, apical half of femora and basal two-thirds of tibiæ yellowish-brown, mid-tibiæ entirely so, tarsi dusky, with black pubescence.

Wings clear; veins dark brown, cross-veins at base of discoidal and adjacent cells faintly clouded brown; stigma yellow; appendix present.

Hab.—N. Territory: Darwin (G. F. Hill).

Type unique. Apparently more closely related to *T. sequens* Walker, than to others of Group ix.

TABANUS SILVIFORMIS, sp.n.

♀. Length, 8·5-11·5; width of head, 3-4; length of wing, 7·75-10 mm.

A small, reddish-brown species, very similar to *Silvius frontalis* Ricardo, in appearance. Thorax, abdomen, and legs reddish-brown. Antennæ reddish. Wings with brown veins, no appendix.

Head: face with cream-coloured tomentum, tomentum on cheeks grey, pubescence brownish; beard pale, very scanty; front with dark-brown tomentum, narrower at the vertex; frontal callus chestnut-brown, almost square, resting on subcallus, nearly as wide as front, with a short, stout, extension; subcallus grey paler in centre; first two joints of antennæ reddish, with grey tomentum and black pubescence, third yellowish-brown, apical annuli darker, base with a small, distinct tooth; palpi slender, basal half of second joint slightly swollen, yellowish, tomentum grey, pubescence black, very sparse.

Thorax reddish-brown, with two, narrow, grey stripes, pubescence pale, brown laterally; scutellum reddish-brown, pubescence pale; pleuræ reddish, with grey tomentum and pubescence.

Abdomen reddish-brown, pubescence brown, brown and black on apical segment, segmentations and pubescence pale, segments one to six with median, apical, pale, triangular spots, with pale pubescence; venter blackish-brown, tomentum, pubescence, and segmentations pale.

Legs reddish, coxæ with grey tomentum, tarsi blackish, pubescence on femora and tibiæ grey, black on tarsi.

Wings clear; veins brown; stigma brownish; no appendix.

Hab.—Q.: Stradbroke Island (H. Hacker).

A species strikingly similar to *Silvius frontalis* Ricardo, in general appearance. It is most nearly related to *T. townsvilli* Ricardo, but is easily separated from it by the thorax, abdomen, and legs.

Type in Queensland Museum; paratype in Institute Coll.

TABANUS TOWNSVILLI Ricardo.

Ann. Mag. Nat. Hist., (8), xv., p.281 (1915).

Four specimens appear to be of this species, and a fifth is included till further material is available. They all differ more or less from the description, but, on the whole, appear to belong to this species.

Hab.—Q.: Brisbane, Stradbroke Island (H. Hacker).

Group x. Species with the abdomen unicolorous, or almost so, sometimes darker at apex.

TABANUS SPATIOSUS Ricardo.

Ann. Mag. Nat. Hist., (8), xv., p.288 (1915).

Hab.—Q.: Stradbroke Island (H. Hacker).

Represented by a single specimen, which agrees well with the description, but the abdomen is very greasy.

TABANUS SANGUINARIUS Bigot.

Mém. Soc. Zool. France, v., p.675 (1892) [*Atylotus*]; Ricardo, Ann. Mag. Nat. Hist, (8), xv., p.287 (1915).

Hab.—N.S.W.: Wauchope (R. J. Tillyard).

TABANUS MINOR, sp.n.

(Plate i., fig.8).

♀. Length, 8-9; width of head, 3; length of wing, 8-8·5 mm.

Head: face grey, lower portion yellowish, tomentum and pubescence grey, cheeks grey; beard grey, scanty; front parallel, black, with brownish tomentum and black pubescence, frontal callus black, shining, pear-shaped, with a short, stout extension. about two-thirds the width of the front and resting on the subcallus; palpi creamy, with black and pale pubescence, fairly stout and ending in a blunt point; first two joints of antennæ yellow with black pubescence; third joint reddish-yellow, with a small angle, some black pubescence on its apex, annuli black.

Thorax black, tomentum brown, pubescence pale; shoulders pale, with black and grey pubescence; pleuræ with grey tomentum and pubescence; scutellum similar to thorax.

Abdomen: first two segments yellowish-brown, the remainder brown with pale segmentations, tomentum brown, pubescence pale; venter similar to dorsum.

Wings: veins brown, faintly clouded with yellowish-brown stigma yellowish-brown; a long appendix present.

Legs yellow, apex of fore-tibiæ brown, fore-tarsi black, mid and hind brown.

Hab. - N. Territory: Darwin (G. F. Hill, Nos.109, 112).

A small, obscure species closely related to *T. nigrimanu* Walker, but differing, *inter alia*, in the antennæ and wings.

Paratype in Coll. Hill.

TABANUS HILLI, sp.n.

(Plate ii., fig.9).

♀. Length, 11·5-13; width of head, 4-5; length of wing, 11-12mm

Head: face and cheeks ashen, lower portion of face yellowish pubescence pale, scanty; beard grey; subcallus reddish-brown with ash-coloured tomentum; front parallel, black, tomentum ellowish, frontal callus dark brown, pear-shaped, with a short ineal extension, about one-third the width of the front; palpi ellowish, second joint moderately slender, ending in a blunt oint, pubescence pale, with a few, scattered, black hairs; first wo joints of antennæ yellow, pubescence black, base of third eddish-brown, annuli black, tooth represented by an obtuse ngle.

Thorax black, with brown tomentum, sides faintly reddish, cutellum similar to thorax, pubescence black, pale laterally; leuræ with grey tomentum and pubescence.

Abdomen brown, first segment darker, with a brown posterior order, segmentations greyish, pubescence black; venter dark rown, with grey tomentum and pubescence.

Legs yellowish-brown, tarsi darker, pubescence mostly black.

Wings clear; veins dark brown; stigma yellow; a short apendix present.

Hab.—N. Territory: Darwin (G. F. Hill, No.67).

This species appears to be related to *T. spatiosus* Ricardo, and o *T. nigritarsis* Taylor, but is readily distinguished from them.

I have much pleasure in dedicating this species to its discoverer.

Paratype in Coll Hill.

TABANUS DAVIDSONI, sp.n.

♀. Length, 15·5; width of head, 5; length of wing, 13 mm.

Head: face yellowish, black on the upper third, with grey omentum, pubescence pale; cheeks with dark brown tomentum nd black pubescence; subcallus dark brown, with a shallow edian groove; front slightly narrower anteriorly, tomentum ark brown, pubescence black, frontal callus about half the width f the front and resting on the subcallus, pear-shaped, with a neal extension reaching the middle of front, black, lower half f basal portion reddish-brown; beard grey; palpi pale reddish, tout, ending in a fine point, pubescence black, dense; antennæ usky-red, annuli black, pubescence black on first two joints, a ell-defined tooth on expanded portion of the third joint.

Thorax dark reddish-brown, tomentum brown, greyish on nterior and posterior margins, two lateral black stripes are visible when denuded, scarcely discernible under the tomentum, sides reddish, pubescence black; scutellum reddish-brown, tomentum brown; pleuræ with grey tomentum and pubescence.

Abdomen reddish-brown, pubescence black, pale on the segmentations and laterally; venter reddish-brown, blackish in the centre and toward the apex, pubescence and tomentum pale.

Legs: forelegs black, basal two-thirds of tibiæ yellowish, with pale pubescence, mid- and hind-femora reddish-brown, pubescence pale, tibiæ yellowish-brown, hind paler, pubescence mainly black, tarsi black, pubescence black.

Wings clear; veins dark brown; stigma pale yellow; no appendix.

Hab.—Q.: Mt. Tambourine (W. H. Davidson *per* R. J. Tillyard).

This is a very distinct species, and is most nearly related to *T. kershawi* Ricardo, but may be distinguished from it, *inter alia*, by the face, cheeks, palpi, and antennæ.

TABANUS PALPALIS, sp.n.

♀. Length, 9; width of head, 3; length of wing, 9·25 mm.

Head: face and cheeks yellowish, pubescence pale; beard pale front yellowish, pubescence black, slightly narrower posteriorly about three and a half times as long as wide anteriorly, fronta callus small, reddish-brown, almost quadrate, about half th width of the front, lineal extension very short and thin; firs two joints of antennæ reddish-yellow, pubescence black, thir joint bright reddish, basal portion broad, no angle or toot present, apical annuli black; palpi yellowish, second joint lon thin (resembling the palpi of *Silvius*), and ending in a blun point, pubescence mainly pale.

Thorax dark olive-buff, shoulders reddish, pubescence pale o the sides, scutellum darker than thorax; pleuræ greyish.

Abdomen reddish-yellow, apex darker, pubescence apparent pale, mostly denuded, venter similar to dorsum, pubescence pal

Legs reddish-yellow, fore-femora and tibiæ darker, tarsi dusk pubescence pale, black on tarsi.

Wings clear; veins brown; stigma lemon-yellow; a long a pendix present.

Hab.—N. Territory: Batchelor (G. F. Hill, No.2).

A species readily distinguished by its palpi and general colour. pparently not closely related to other species of Group x.

roup xi. Species with pubescence on the eyes (*Therioplectes*).

TABANUS CIRCUMDATUS Walker.

List. Dipt., i., p.185 (1848); Ricardo, Ann. Mag. Nat. Hist.,), xvi., p.280 (1915); White, Papers and Proc. Roy. Soc. Tasania, 1915, p.14; Taylor, Records Aust. Museum, xii., No.5, .67 (1918).

Hab.—N.S.W.: Palm Beach (R. J. Tillyard), Cordeaux Dam *er* W. W. Froggatt).—Victoria: Gisborne (G. Lyell *per* R. J. illyard).—Tasmania: George Town, St. Helen's, Mt. Arthur (F. . Littler).

TABANUS REGIS GEORGII Macquart.

Dipt. Exot., i., p.132 (1838); Ricardo, Ann. Mag. Nat. Hist.,), xvi., p.276 (1915).

I refer two specimens before me, provisionally, to this species. hey agree with Miss Ricardo's note on the species, and also ear some affinity to the description of *T. postponens* Walker, hich, Miss Ricardo states, it closely resembles.

Hab.—Q.: Townsville (Dr. A. Breinl).

TABANUS BRISBANENSIS Taylor.

(Plate ii., figs.10, 11).

Proc. Linn. Soc. N. S. Wales, 1917, xlii., p.526.

Three specimens before me bear a striking similarity to this ecies, differing only in having the annuli of the third joint of tennæ black, the basal portion broad, with a shallow angle; e frontal callus is slightly larger, with a short, stout, extenon; the beard is also distinctly yellowish. These distinctions e not sufficient to separate them specifically.

Hab.—Tasmania: St. Helen's, George Town, and St. Mary's M. Littler, No.2741).

In describing the type, I inadvertently described the frontal llus inaccurately, owing to the surrounding frontal area being ossy. It should read as follows:—Frontal callus a reddish-brown, shining, irregularly oval plug without a lineal extension, its base about half the width of the front and resting on the subcallus. The annuli of the third joint of the antennæ are also slightly dusky.

TABANUS KENDALLENSIS, sp.n.

♀. Length, 9 5-10; width of head, 4; length of wing, 9 mm.

Head: face and cheeks with grey tomentum and pubescence; beard grey; front about one-third wider anteriorly, tomentum golden-yellow, brownish on the vertex, pubescence black, frontal callus shining, dark reddish-brown, almost square, about two-thirds the width of front and resting on subcallus, with a stout, black, lineal extension reaching the middle of the front; subcallus yellowish, with grey tomentum; palpi yellowish, tomentum grey, pubescence mainly black; first two joints of antennæ pale reddish-yellow, pubescence black [third joint wanting]; eyes greenish, when moistened, and very faintly pubescent.

Thorax black, with brown tomentum and erect black pubescence with numerous golden hairs, sides reddish, with long pubescence, mainly dark, scutellum similar; pleuræ grey with long grey pubescence.

Abdomen: first three segments ochraceous-orange, with a broad median, black stripe, second to fifth segments with median, triangular, golden-haired flecks, base of first dusky, segments fou to the apex black, with lateral margins ochraceous-orange tomentum yellowish, pubescence black, pale on the posterior and lateral margins, segmentations ochraceous-orange; venter with the first three segments reddish-yellow, rest black, tomentum greyish, pubescence pale.

Legs black, basal half of fore-tibiæ yellowish-brown, mid- and hind-tibiæ paler; coxæ and femora with grey tomentum, pubescence black, a few pale hairs on the femora and tibiæ.

Wings clear; veins dark brown, yellowish at the base; stigm yellow; an appendix present.

Hab.—N.S.W.: Kendall (R. J. Tillyard; 25.2.17).

A species close to *T. neobasalis* Taylor, but differing markedl in the clothing of the front, and in the legs.

TABANUS ROBUSTUS, sp n.

♀. Length, 17; length of wing, 14; width of head, 6 mm.

Head: face and cheeks covered with white tomentum and ibescence, the latter fairly long on the face; beard white, dense; rst two joints of antennæ deep red, with black pubescence, and attered, white and grey hairs on inner sides; third joint miss- g; palpi reddish-yellow, tapering to a blunt point, pubescence hite; subcallus covered with grey tomentum; front broad, nar- wer at vertex, tomentum greyish-white, vertex with brown mentum; frontal callus black, shining, as wide as front, resting subcallus, and gradually tapering to a blunt point, ending out the middle of the front; eyes black, pubescence short and le.

Thorax pale reddish, with grey tomentum, a broad, median, rk brown stripe terminating on a level with the wing-roots, om whence it is continued to the scutellum as a very narrow e, on either side is a brown stripe the full length of the thorax, d a short one above the wing-roots; shoulders yellowish, lateral ibescence grey, dorsally dark on the stripes, grey elsewhere; utellum dark, posterior border grey; pleuræ grey, with patches long, grey pubescence.

Abdomen: first segment dark, with grey tomentum, posterior rder yellowish except centrally, remaining segments somewhat easy, appearing brown, segmentations paler, with remains of ey tomentum; venter black, segmentations pale, tomentum ey, pubescence grey, scattered.

Legs: coxæ and femora grey, with long, grey pubescence, the ter shorter on the femora, fore-tibiæ pale red-brown, mid dark d-brown, hind black, pubescence pale, tarsi black, pubescence ack, hind-tibiæ with a dense white fringe of hairs on the ternal margin.

Wings clear; veins dark brown; stigma yellowish-brown; ap- ndix present.

Hab.—Q.: Brisbane (H. Hacker; 29.10.17).

A very distinct and robust species, not closely related to any ecies known to me. The white fringe on the hind-tibiæ is very ticeable.

Type in the Queensland Museum.

TABANUS GERALDTONENSIS, sp.n.

(Plate i., fig.12).

♀. Length, 12; length of wing, 11; width of head, 4·5 mm.

Head: face and cheeks grey, with grey pubescence; subcallu pale dirty yellow; front parallel, grey, yellowish toward the bas and along the sides, pubescence black, frontal callus about on half the width of the front at base, deep red, flask-shaped, wit a stout, lineal extension reaching the middle of the front, a fe black hairs on the vertex; eyes black, pubescence very short an scanty; first two joints and basal half of base of third joint du reddish, rest of basal portion of third joint dusky, annuli blac pubescence on first two joints mainly black; palpi slender, abou two-thirds the length of proboscis, yellowish, ending in a fin point, pubescence yellowish, beard grey.

Thorax black, shoulders obscurely reddish, tomentum gre pubescence black and golden, grey on sides, scutellum similar t thorax; pleuræ obscurely black and reddish, tomentum an pubescence grey.

Abdomen reddish-brown, darker on last three segments, se ments one to four black in the centre, all segments with media grey, triangular spots, with their bases resting on the posteri border, segmentations and sides of segments yellowish, pube cence black, pale on the pale areas; venter reddish, black in th centre, pubescence pale.

Legs: fore-coxæ pale, with long, grey pubescence, mid ar hind dusky, tomentum and pubescence grey, the latter short than on fore-coxæ, femoro-coxal joint of foreleg slate-coloure fore-femora and basal half of tibiæ yellowish, the rest dusky, mi femora and tibiæ yellowish, tarsi dusky, basal half of hind-femo dusky, the rest yellowish, tibiæ and tarsi wanting, tarsi of fo and midlegs black, pubescence pale and dark on femora, bla on tibiæ and tarsi.

Wings clear; veins brown; stigma yellow; a small append present.

Hab.—W.A.: Geraldton (J. Clarke, Coll. W. W. Frogga No.75 F).

Closely related to *T. antecedens* Walker, but differing in havi smaller frontal callus, in the absence of stripes on the thorax, nd in the scanty pubescence on the eyes. The abdomen and gs also differ.

TABANUS POSTPONENS Walker.

List. Dipt., i, p.179 (1848); Ricardo, Ann. Mag. Nat. Hist.,), xvi., p.282 (1915); Taylor, Records Aust. Mus., xii., No.5, .69 (1918).

Hab.—Q.: Stradbroke Island (H. Hacker).

Two specimens, ♂♀, the latter agreeing well with Miss icardo's description. The male has already been described by e from a specimen in the Australian Museum Collection.

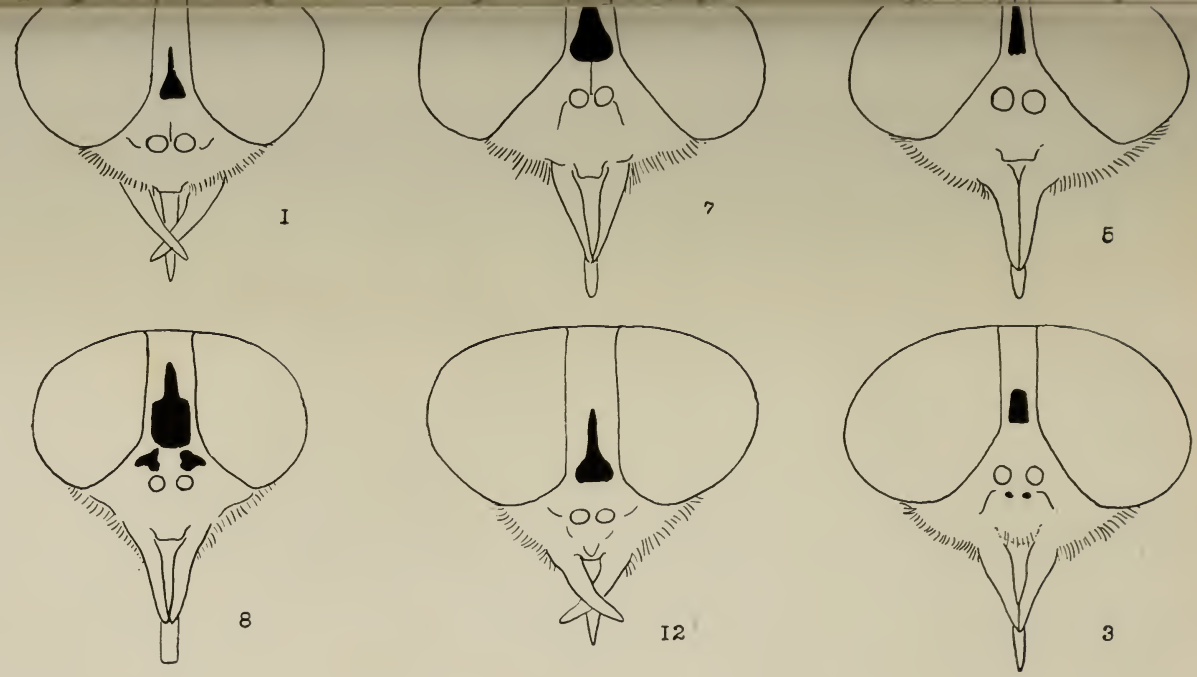
EXPLANATION OF PLATES I.-II.

Plate i.

Fig.1.—*Tabanus walteri*, sp.n.
Fig.3.—*T. obscurilineatus*, sp.n.
Fig.5.—*T. kurandae*, sp.n.
Fig.7.—*T. atmophorus*, sp.n.
Fig.8.—*T. minor*, sp.n.
Fig.12.—*T. geraldtonensis*, sp.n.

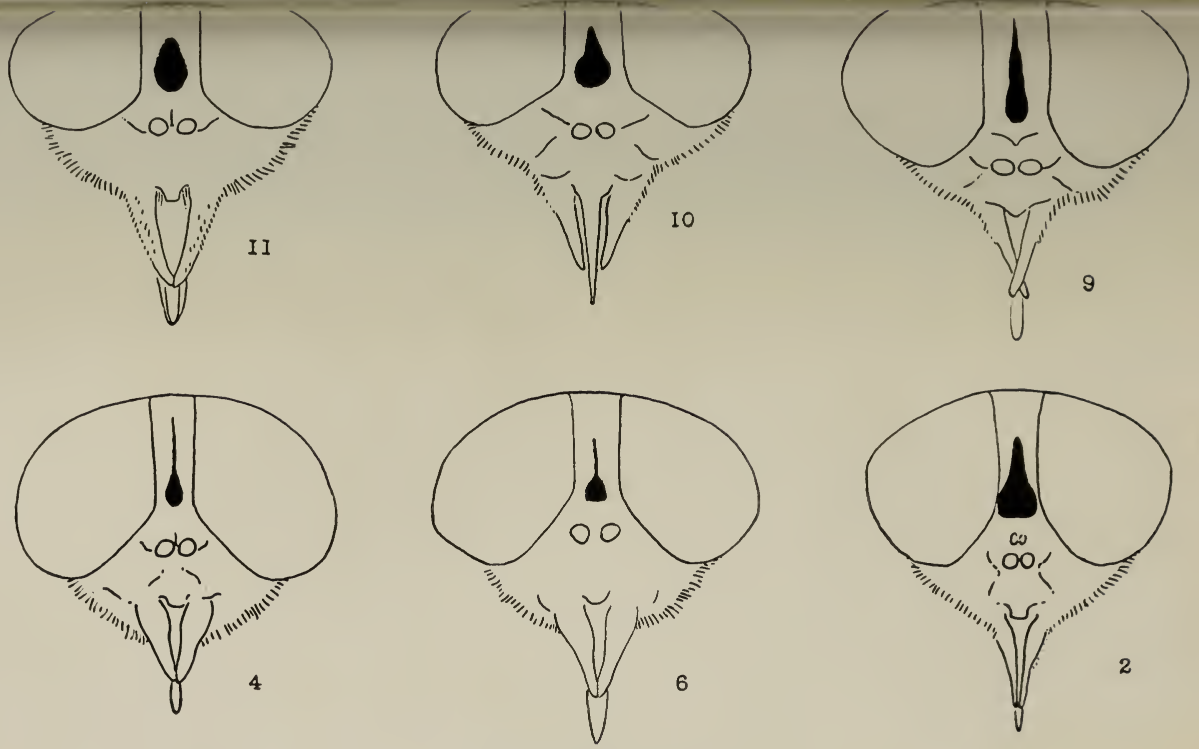
Plate ii.

Fig.2.—*Tabanus eidsvoldensis*, sp.n.
Fig.4.—*T. obscurimaculatus*, sp.n.
Fig.6.—*T. batchelori*, sp.n.
Fig.9.—*T. hilli*, sp.n.
Fig.10.—*T. brisbanensis* Taylor, from Queensland.
Fig.11.—*T brisbanensis* Taylor, from St. Helen's, Tasmania.



Phyllis F. Clarke

Australian Tabanidæ (*Tabanus*)



Australian Tabanidæ (*Tabanus*)

eprint from *The Medical Journal of Australia*, May 3, 10 and 17, 1919.

TROPICAL AUSTRALIA AND ITS SETTLEMENT.

By **A. Breinl** and **W. J. Young**.

(From the Australian Institute of Tropical Medicine, Townsville.)

Contents.

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Introduction.

Tropical Australia and its settlement by a British ce has formed the theme of numerous public utter- ces and of a good deal of writing in both the scien- ic and lay press. Sometimes these utterances have en dictated by ultilitarian reasons alone, sometimes ey have only formed part of a general political opaganda; many have been influenced by personal ejudice and were put forth by writers whose ex- rience of life in Northern Australia did not qualify em to express an opinion on this subject.

On many occasions, when the ultimate fate of North- n Australia has formed the subject of discussion at rious scientific meetings, the speakers have applied discriminately to Northern Australia the outcome of periences gained by themselves or by others in vari- s parts of the tropics, without realizing that North- n Australia occupies a different position, on account the absence of a settled native population and its culiar climatic conditions.

The following pages are the outcome of several ars' investigation in and consideration of conditions taining in Northern Australia and their influence on a settled white race. A résumé is included of evious investigations [illegible] other workers into the prac- ability of a white se[illegible] parts of the pics and the influe[illegible] tropical life upon a popu- European descent. An attempt is made to and to review the results of previous investi- ublished in numerous scattered journals, hich, with the exception of the experiments t in the Philippine Islands, have not only in a haphazard way, but sweeping con- ave been based upon a few unsystematic ns.

blem of the settlement of tropical Australia by a white race is a very difficult and complicated one, since two factors enter into the question. In the first place, climatic conditions and their effect upon the white man are of paramount importance, since racial degeneration, brought about by climatic conditions alone, would decide the problem. At the same time the economic side of the question plays an important part and cannot be neglected, and a discussion on this aspect has been included.

Opportunity is taken here to thank Mr. H. A. Hunt, the Commonwealth Meteorologist, for putting at our disposal the climatic data, and also Mr. G. H. Knibbs, C.M.G., the Commonwealth Statistician, for help and suggestion in connexion with the statistical data.

The Climate of Northern Australia.

The Australian living in the southern parts of his continent generally possesses only a very uncertain knowledge of the climate of the northern parts. He assumes that the whole of the north above the tropic has a uniformly hot climate, that heat and mugginess persist and that a feeling of personal comfort is only a rare sensation. This popular conception arises from the general idea of "tropics"; most people in their early youth associate with "tropics" a land of impenetrable jungle, heat, swamp and fever, an impression gained by reading books of adventure and travel.

The scientific study of climates within the tropics shows, however, that there exists a great diversity of climatic conditions, regulated by a number of factors, such as the nearness to the ocean, elevation above sea level, proximity to high mountain ranges which control rainfall, prevailing wind and, above all, the amount and monthly distribution of the rainfall.

To describe climate from the point of view of its effects upon a human race is impossible with our present means. It is only to a certain extent that climate, as we feel it, finds a graphic expression in those meteorological observations usually recorded, which measure heat and humidity only, namely, the readings of the dry and wet bulb thermometers. From these readings is further calculated the relative humidity, that is, the extent to which the atmosphere is laden with moisture. The degree of personal comfort or discomfort experienced is indicated to some extent by these readings, but it is certain that many other factors play a large part in determining individual sensations.

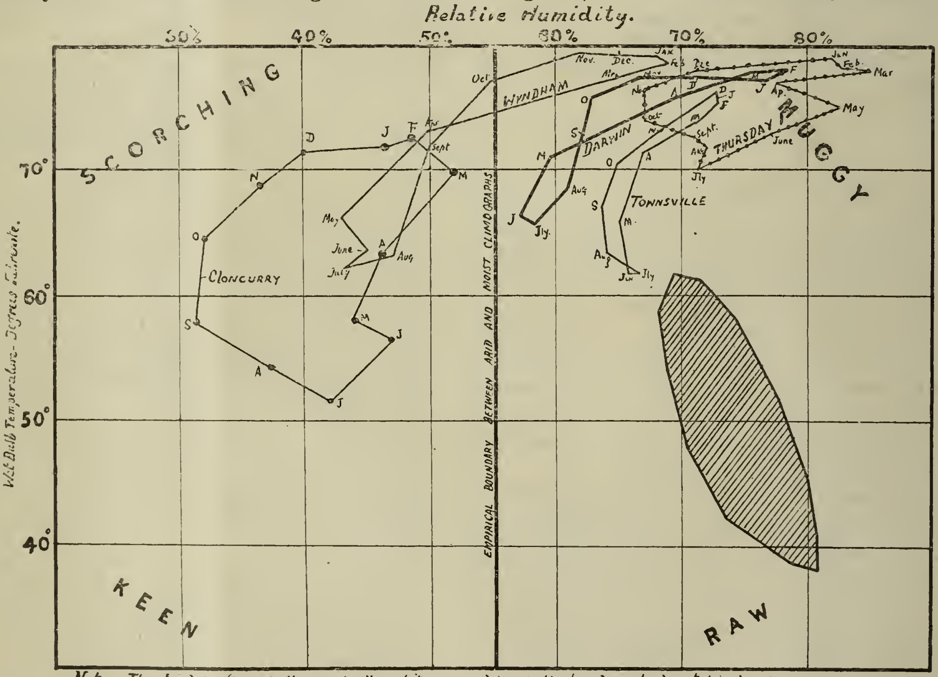
Numerous attempts, summarized as far as 1908 by Hann, have been made to construct a "discomfort scale," but no satisfactory solution has yet been attained. Conspicuous amongst these is that of Cleveland Abbé, who suggested a "curve of comfort," based upon three factors, namely, air temperature, relative humidity and wind velocity. By plotting temperatures against humidities for a certain velocity of wind and estimating personal comfort or discomfort under these conditions, he obtained charts which correlated his personal sensation with the above factors.

Wet bulb temperatures alone were first used as a guide to comfort by Harrington, who termed them "sensible temperatures" and mapped out wet bulb isotherms for the United States of America for the month of July. The importance of wet bulb readings has been further emphasized by Haldane (1905), who demonstrated experimentally that the regulation of body temperature above a certain wet bulb reading became disorganized and human energy was paralysed. He therefore suggested wet bulb temperatures as a standard by which to regulate conditions in factories, mines and workshops.

Griffith Taylor (1916) has suggested a tentative scale of discomfort, applying only to warmer regions, where humidity and temperature are the chief factors, a scale depending on wet bulb readings. He divided "climate" into the following grades:—

8.3°-12.7° C.	(45°-55° F.)	wet bulb—Most comfortable.
12.7°-15.5° C.	(55°-60° F.)	wet bulb—Very rarely uncomfortable.
15.5°-18.3° C.	(60°-65° F.)	wet bulb—Sometimes uncomfortable.
18.3°-21.1° C.	(65°-70° F.)	wet bulb—Often uncomfortable.
21.1°-23.7° C.	(70°-75° F.)	wet bulb—Usually uncomfortable.
Over 23.7° C.	(over 75° F.)	wet bulb—Continuously uncomfortable.

A rough-and-ready indication of the degree of discomfort, used by Osborne (1916), is the amount of clothing required to enable him to lie with comfort in an open meshwork hammock. His experiences have led him to set a wet bulb of about 22.75° C. (73° F.) as an empirical standard above which truly tropical conditions arise.



Note.- The shaded figure is the composite white race climograph based on twelve typical cities

FIGURE I.

Many authors, however, contend that wet bulb readings alone are not an unerring indication of the subjective sensation caused by climate. L. Hill (1914, 1916), for example, pointed out: "It is no use to trust to the ordinary thermometer, either wet or dry, because it does not show heat loss. It only shows its own temperature, the average temperature of the furniture, surroundings and walls; it does not show the heat loss of the body. Whilst the thermometer is a static instrument indicating average temperature, the human body is a dynamic structure, continually producing and losing heat, while its temperature remains sensibly constant." He deprecated the use of relative humidity as a criterion of comfort, and suggested the katathermometer, a new apparatus, which would register the rate of heat loss and thus indicate more closely the effect of temperature and atmospheric conditions upon the human body. Thi instrument consists of two thermometers, each havin a large bulb filled with alcohol; one of these is kep dry—the dry bulb katathermometer; the other i kept moist by means of a wet cotton glove—the we bulb katathermometer. Both are heated to 43.3° ((110° F.) and the time which each takes to cool fro 43.3° to 32.2° C. (110° to 90° F.) is noted. The dr bulb katathermometer thus measures the rate of coo ing by convection and radiation, the wet bulb kat thermometer that by convection, radiation and eva oration and thus measures not the actual air ter perature but the rate of cooling of a moist body, du to the effects of the atmospheric condition at an actu temperature approximating to that of the huma body. Practical experience has shown, however, th the wet bulb katathermometer is too sensitive to a currents. Osborne (1916) has pointed out that series of readings taken in rapid successio yields fairly uniform results only in still a indoors, or outdoors if a steady breeze blowing. On the other hand, when the wind com in gusts, consecutive readings show great variatio Observa tions i Towns ville with t katathe momete have confir ed Osborn exper ence a have prov that ca weather, far as katath momet readings e concerned, a rare exc tion and d classed still to p sonal ser tion may be so to katath mometer.

Griffith Taylor (1916) attempted to overcome difficulty of judging a climate in a novel manner, introducing a graphic representation, termed a cli graph, produced by plotting the monthly means of lative humidity against monthly means of wet b readings. He compiled as a standard a compo climograph, by using average figures for towns s ated in regions where human energy is at its b selecting for this purpose five towns in the south and seven towns in the northern hemisphere, w the average monthly wet bulb readings range e- tween 2.7° and 16.6° C. (37° and 62° F.). T climograph, according to Taylor, represents ide co ditions for the white race, and he terms it the "w race climograph." On the same principle e c structed a number of climographs for differe p

the world and differentiated in this way four ex-
me climatic types—hot and damp, hot and dry,
l and damp and cold and dry—and compared the
nographs of Australian towns with these .types
e Fig. I.). The shape of the climograph also indi-
es the seasonal
tribution of rain-
.

t is an ingenuous
l striking method
comparing in a
eral way the cli-
e of any given lo-
ty with a type,
does not convey
further informa-
than the mean
dings of dry and
bulb thermome-
, and it is signifi-
t that Taylor him-
, when discussing
question of dis-
fort in relation to
ate, uses the wet
readings as
le.

ruce (1916) has
posed the use of
point as an indi-
r of the effects of
ospheric condi-
s upon the hu-
body, and comes
he conclusion that
dew point most
rable for human
vity is 16.6° (62°
that is to say,
air saturated
h moisture at
° (62° F.) is
her muggy nor
lly. If the
point, however,
s over 21.1° C.
F.) the condi-
s become exceed-
y trying.

his principle has
applied to the
age temperatures
rded in Towns-
and the re-
have indicated
the dew point
9 p.m., is, as
ule, higher than
9 a.m. or 3
, although the
litions in the evenings are, on the whole, undoubt-
less trying than those prevalent during the day.
thermore, this principles does not take into ac-
t the effects of other conditions, such as wind and
hine.

It would appear, therefore, that neither humidity nor dew point give any more information in regard to personal comfort than the readings of dry and wet bulb thermometers.

Hunt, at Osborne's suggestion, constructed wet bulb isotherms for Australia—the only part of the world for which such complete isotherms have been published — attempting thus to represent graphically climatic conditions as far as personal comfort is concerned. As pointed out previously, wet bulb temperatures alone in this respect are only of limited value, since experience has shown that, although high wet bulb temperature, approaching the limit of safety, may be a guide to discomfort, yet lower ones, without the accompanying dry bulb readings, are indefinite. From our personal experience, wet bulb readings above a certain limit invariably denote discomfort, yet the dry bulb temperature even then modifies the degree of discomfort felt. For example, a wet bulb reading of 26.6° C. (80° F.) is never pleasant, but the degree of discomfort becomes exaggerated in direct proportion to the dry bulb reading. For these reasons it has been thought advantageous to make use simultaneously of the mean dry and wet bulb readings for the comparison of the various parts of Northern Australia. In the accompanying graphs (Fig. II.) are plotted the average monthly dry and wet bulb temperatures, taken at 9 a.m. over a period of five years, and the points are connected by lines for distinctness only, the 10° C. (50° F.) line being indicated in order to make a comparison easy. Since the temperatures are so dependent on the rainfall,

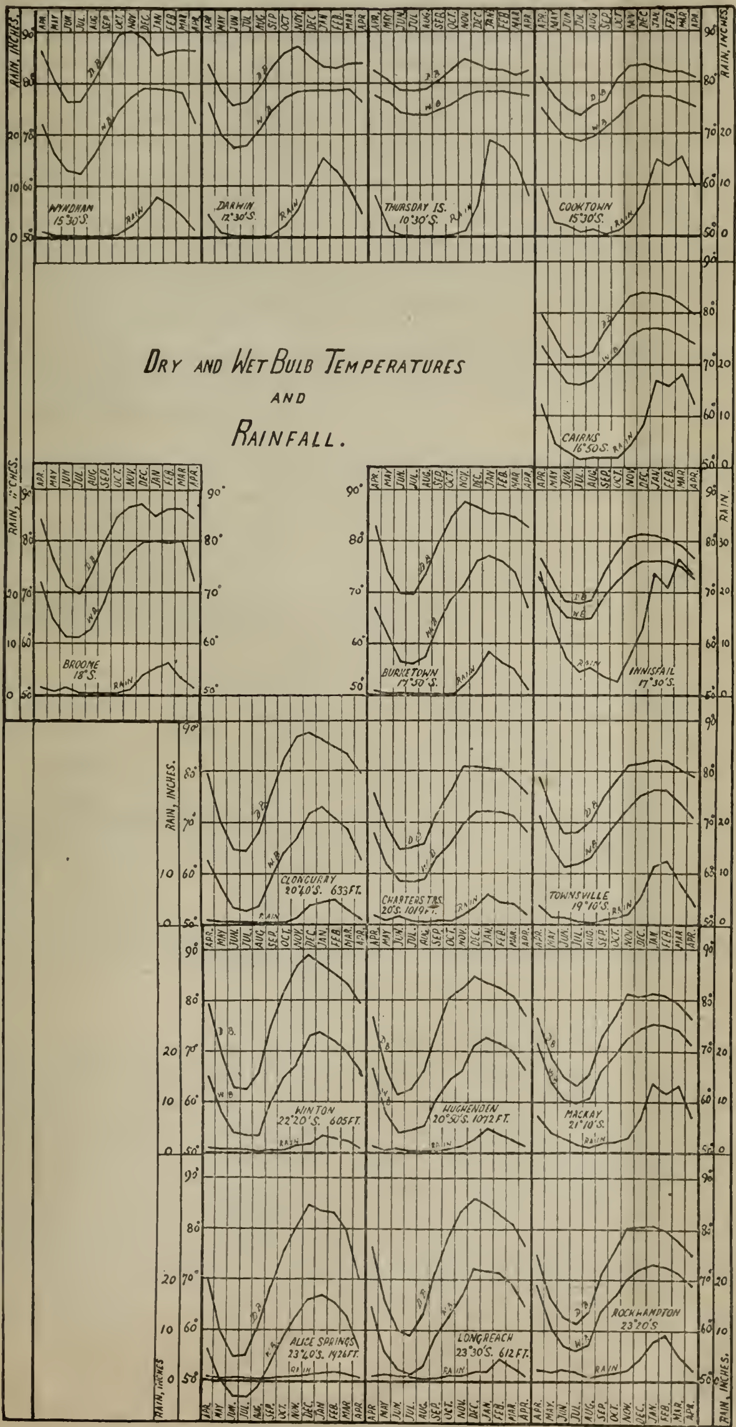


FIGURE II.

average rainfalls obtained from Hunt's publications have been plotted in these charts. The relative positions of the graphs of the various towns are arranged diagrammatically as near as possible in accordance with their geographical position (compare map, Fig. III.). Thus the coastal towns are represented on the outside of the diagrams and the inland towns in the interior. The graphs commence with the month of April, as in this month a distinct change of season sets in; beginning from then, the average temperature falls (rapidly at first and more gradually afterwards) and begins to rise again on or about July. In this way both fall and rise are more conveniently displayed for comparison than if the graphs were commenced with January in the usual way. In order to make the comparison more complete, the monthly averages for the maximum and minimum temperatures are displayed in a similar manner on a second series of charts (Fig. IV.).

The graphs make it clear that the climate of the coastal towns differs essentially from that of the inland towns. The former towns have, on the whole, higher wet and lower dry bulb readings than the latter. With the coastal towns the average readings increase gradually with decreasing latitude and the contrast between the cool and hot season becomes less and less pronounced. The charts of Rockhampton and Thursday Island, the two extreme towns of Queensland, situated within the tropics, illustrate this contention. In Rockhampton (latitude 23° 24′) the coolest month (July) has average dry and wet bulb readings of 16.3° C. (61.4° F.) and 13.3° C. (56° F.) respectively and the hottest month (January) has readings of 27° C. (80.6° F.) and 22.7° C. (73° F.) respectively. The average dry bulb temperature is therefore 10.7° C. (19.2° F.) higher and the average wet bulb reading is 9.4° C. (17° F.) higher in January than in July. In Thursday Island, however (latitude 10° 34′), the corresponding averages are 25.8° C. (78.3° F.) and 23.2° C. (73.8° F.) for July respectively and 28.1° C. (82.7° F.) and 25.9° C. (78.7° F.) for January, showing much smaller differences, namely, 2.3° and 2.7° C. (4.4° and 4.9° F.) respectively. In other coastal towns, such as Darwin, Wyndham and Broome, situated on the northern coast of Australia, the seasonal variations are more pronounced when compared with Thursday Island. During the hot season the average readings there are higher than in towns on the eastern coast in the s latitude. Broome and Innisfail, for example, both s ated between 17° and 18° South, show this differe in a marked degree (see charts), but the geograph position alone explains this difference, since Innis lies within the region of the trade winds, and, in a tion, possesses a larger rainfall.

For comparison only, graphs representing the mates of Daru, Port Moresby and Samarai, all Papua, have been added (Fig. V.). These graphs not differ essentially from those of Thursday Isla

In most of the inland towns of Northern Austr weather conditions are greatly influenced by altit and changes with latitude are consequently pronounced.

The graphs representing the average maximum minimum temperatures exhibit the same seaso variations, which in the coastal towns become marked with decreasing latitude and show sma ranges of temperature. In the inland towns the a age maximum readings in general are much hig and the average minimum readings much lower t in towns the sea c

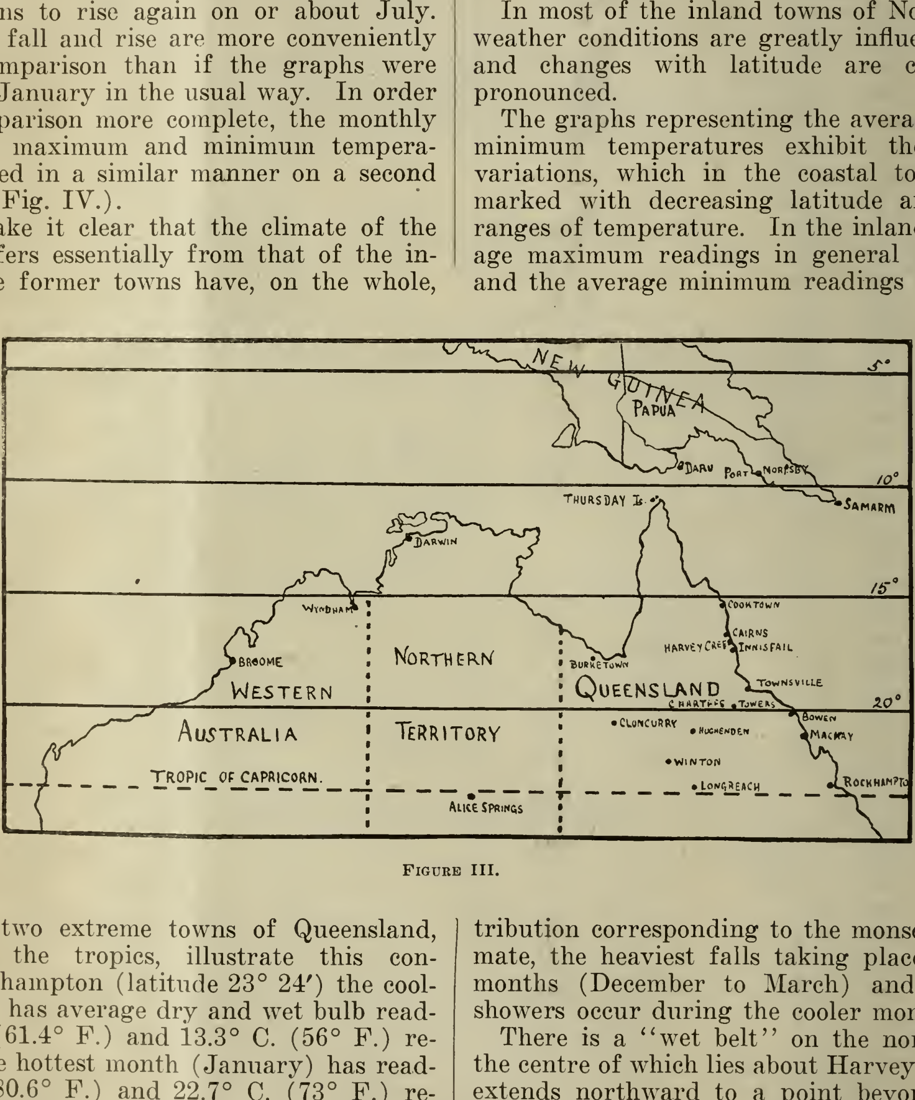


FIGURE III.

A com hensive count of distri tion of r fall thro out North Australia been p lished Hunt in ries of m graphs is by the terolo cal Bu The rai in No Quee land sho seasonal tribution corresponding to the monsoonal type o mate, the heaviest falls taking place during th months (December to March) and only occas showers occur during the cooler months.

There is a "wet belt" on the north-eastern the centre of which lies about Harvey Creek and extends northward to a point beyond Port Do and southward as far as Halifax, where a very general rainfall is registered (see Table I.).

TABLE I.—RAINFALL.

Cooktown	181.9 cm.	(71.6 inch
Port Douglas	210.6 cm.	(82.9 inch
Cairns	229.9 cm.	(90.5 inch
Harvey Creek	426.0 cm.	(167.7 inch
Innisfail	384.0 cm.	(151.2 inch
Cardwell	218.6 cm.	(86.1 inch
Halifax	226.6 cm.	(89.2 inch
Ingham	204.5 cm.	(80.5 inch
Townsvilile	125.2 cm.	(49.3 inch

The inland towns, on the whole, are much drie the coastal towns and show a similar seasonal bution of rainfall.

n the coastal towns of other parts of Northern Aus- ia conditions similar to those of North Queensland vail, with the one difference that Broome and ndham show a comparatively small average rain- , namely, 58.2 cm. l 71.4 cm. (22.9 hes and 28.1 inches) pectively. In New inea, Port Moresby l Daru, both situ- d within the mon- nal belt, possess in same way a dry l wet season, whereas narai has its rainfall 296.4 cm. (116.7 hes) more evenly dis- outed over the whole the year.

nlight in the Tropics.

he main difference ween a temperate l a tropical climate in the greater in- sity of the sun's rays the tropics. This ater intensity is ly due to the less ique path of the rays riking the earth, ereby they have sed through a smaller er of atmosphere. As esult, a less degree of orption and scatter- has taken place, and chemical and physi- activities of these s are therefore great- the nearer to the ator. This greater vity of the sun's s manifests itself in ryday life. The new- ner to the tropics n becomes aware that oured materials, such curtains, carpets and hing fade quickly written matter in when exposed to sun, gradually gets hter, and, after a e, almost disappears. ilarly, a number of mical preparations ompose, rubber rap- perishes and cer- qualities of glass altered. The frost- of glass flasks, microscopic slides and high er lenses are examples only too well known laboratory workers in the tropics.

he bactericidal action of sunlight has been known for a long time and has been investigated again recently by Clemesha (1912) in India, who exposed cultures of fæcal bacteria to the sun. In other experiments he added large quantities of fæces to water contained in a tank with a large surface area (0.6 hectares, or 1 acre) exposed to the sunlight and examined the liquid from day to day for bacterial content. Furthermore, he studied the bacteriological flora of waters of natural lakes during the monsoonal and dry seasons. All these inquiries led him to conclude that the sun has a very powerful action in destroying fæcal organisms in water.

Such changes as the above, together with numerous others of a similar nature, led to the question of the nature of the rays producing these results. Are they brought about by those rays of shorter wave length in the violet and ultra-violet portions of the solar spectrum (chemical rays), or are they to be attributed to rays of longer wave length, situated at the other end of the spectrum, the red and infra-red rays (heat rays)? The ultra-violet rays are known to increase chemical activity and many chemical reactions and decompositions may be brought about by exposure to these rays. An example is the decomposition of oxalic acid into carbon monoxide, carbon dioxide and water when exposed to the sun in the presence of a uranium salt. This decomposition is almost entirely due to those rays of the solar spectrum in the ultra-violet extending from 550 $\mu\mu$ to 291 $\mu\mu$ (Freer, 1912). Observers in the Philippines attempted to make use of this decomposition of oxalic acid under standardized conditions, in order to compare the intensity of the ultra-violet rays of the sun in different

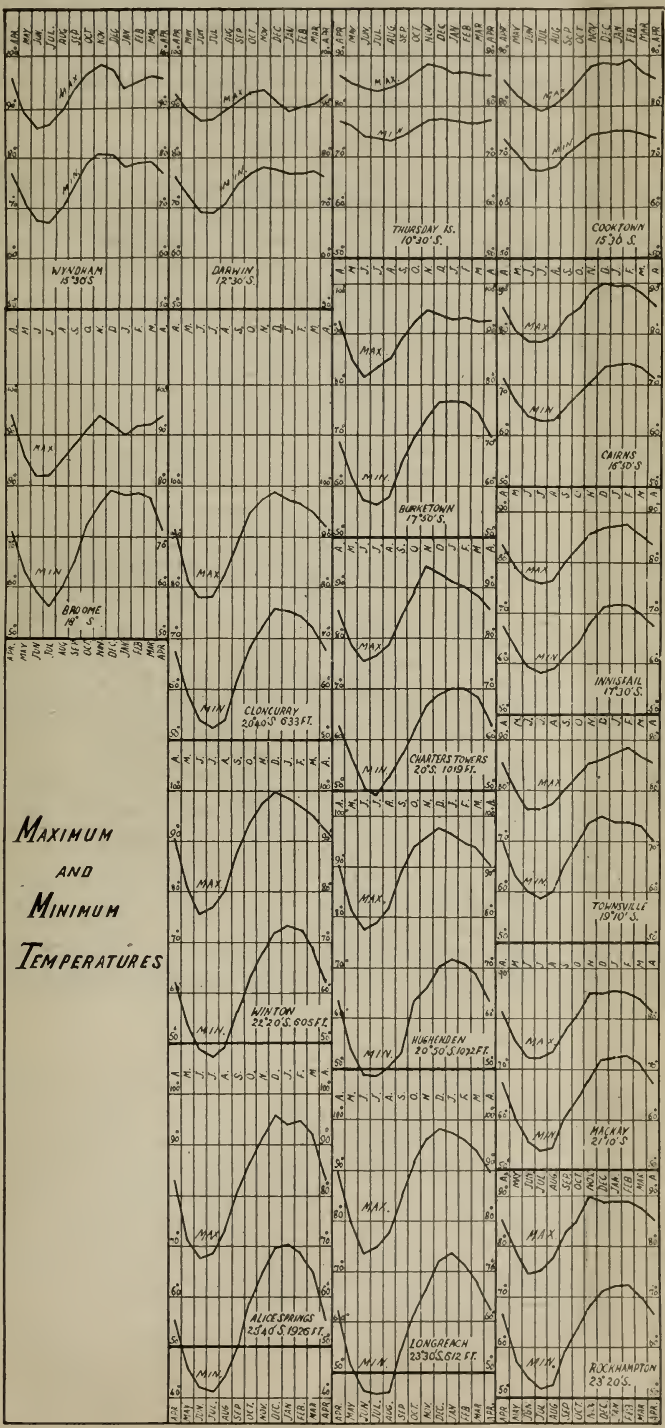


FIGURE IV.

parts of the world. The results, however, showed that the amount of decomposition in the Philippines and other parts of the tropics was inconstant and did not bear any definite relationship to latitude. The figures obtained by the same method in a temperate zone were sometimes as high and even higher than those found in the tropics.

The extensive observations of the Philippine workers have led them to the conclusion expressed by Aron (1911): "That the spectrum of the sun's rays does not extend much, if any, further into the ultra-violet in Manila than in northern climates." These observers do not agree with Woodruff (1905) and others, who attribute the effects of tropical sunlight on the human organism to the influence of ultra-violet rays only. Aron (1911) believes that "the rays of the tropical sun, having greater wave length than those in the red and ultra-red end of the spectrum, play the most important rôle in producing the untoward effects generally attributed to tropical sunlight"; in other words, he attributes such effects to the heat rays alone.

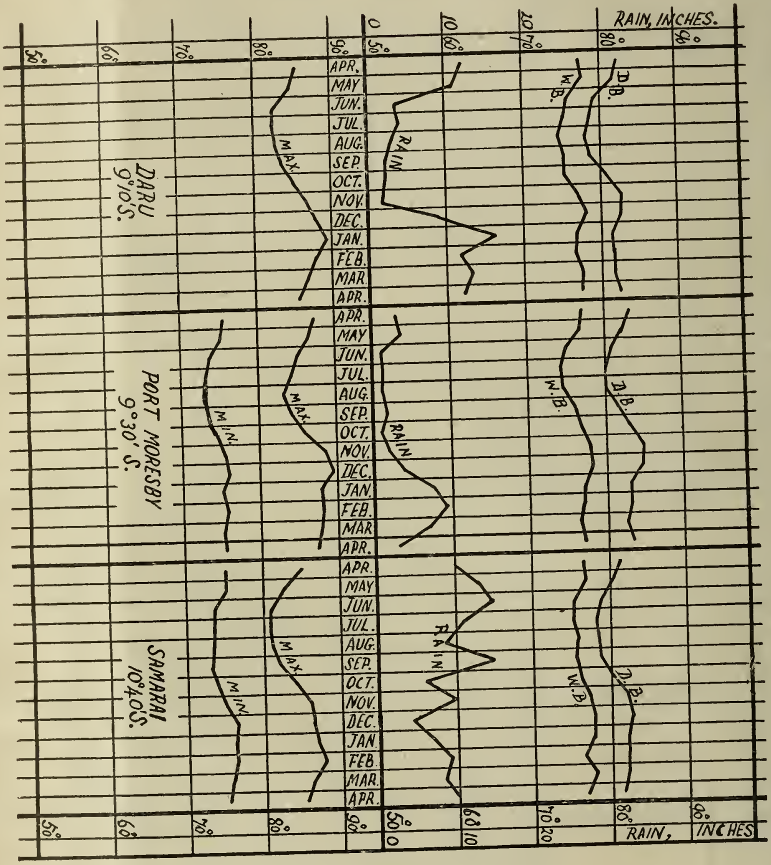


Figure V.

Gibbs (1912), working in conjunction with Freer and Aron, expresses a somewhat similar opinion, and, if altitude and local meteorological conditions are taken into consideration, he does not believe that "when the normal intensities are compared, the light of the tropics is different from the sunlight of any other region." Effects upon life in the tropics, usually attributed to sunlight, are, in his opinion, due to "other meteorological modifications, which go to make up climate, namely, duration of sunshine, clouds, rainfall, winds and humidity, all of which affect the air temperature; the last is probably the most important fact and depends to a large extent upon the duration of sunshine."

In Manila and Baguio, both in the Philippines, Aron (1911) and Gibbs (1912) carried out experiments on animals in order to study the effects of exposure to the sun's rays under varying conditions. Different experimental animals, such as rabbits and monkeys, were exposed to the midday sun for varying periods. These animals, when shielded from draughts, died after an exposure of from thirty-fo minutes to about one and a half hours, and showed t post-mortem appearances characteristic of heat strol Black rabbits, as a rule, succumbed more quickly th light-coloured animals and it was noticed that the su cutaneous temperatures, taken by means of a therm couple, in the case of black rabbits, rose quicker a higher than in that of the lighter-coloured ones.

Aron, furthermore, carried out exposure expe ments on dogs which had been tracheotomized a thus had part their effective he regulating mech ism put out of tion.[1] It is w known that dogs not possess sw glands on the bo but keep their b temperature fr rising by means an increased rate respiration and increased evapo tion from their piratory tract. Th animals died a about an hour w typical symptom heat stroke and responding po mortem appe ances. In a sim manner the b temperatu of tracheotom rabbits rose on posure to the more rapidly that of normal bits.

When mon were exposed t artificial dra during the ex ment, or were protected by shade from direct sun rays, no injurious effects noticed. These experiments, according to Aron (19 show that "when placed under the fan animals the excessive heat which reached them by radia from the sun. Rays including the ultra-violet nevertheless present and were absorbed by the in the same manner and degree as by that of the trol monkeys."

These experiments have recently been repeate Shaklee (1917) and further amplified, to asce whether it is possible for monkeys to become a tomed to the sun (acclimatized) by a graduall creasing daily exposure. His results differed those of Aron, as several of his monkeys, even i beginning of the experiment, lived for hours i irect sunlight without being protected in any way. ummarizing his results, he states that experimental onkeys, exposed to the sun in Manila, may die from eat stroke after varying periods, depending to a less tent upon the sun's rays than on other local con- tions, such as proximity of a large, hot surface round or roof), high relative humidity of the atmo- here and low wind velocity. Monkeys, however, ay become temporarily acclimatized by gradually in- easing the time of exposure to the sun. This, in his inion, increases the sensitiveness of the nervous echanism which regulates body temperature by an creased rate of perspiration. The fact that adminis- ation of atropine, which impairs the function of the eat glands, causes the death even of an acclimatized onkey on exposure, is evidence in support of this nception.

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[1] Considering the relatively small surface of mouth, nose and above the tracheotomy wound, compared with the breathing surface lungs, it is evident that the operation had put out of action only tremely small portion of the respiratory surface, and cannot alt account for the quicker death of these animals.

Animal experiments were also carried out by hmidt, who, working in a temperate climate, ex- sed rabbits to the sun and found a rise in the anal mperature which was more pronounced in a black an in a white rabbit. In the same way Schilling 909) observed a rise in the skin temperature of rab- ts exposed to the sun and several other authors have ade similar observations. It must be kept in mind, wever, that the temperature of rabbits varies con- lerably even under normal conditions, and the ruggling alone, when the animal is handled, may use a considerable rise.

It is not a new observation that animals, even in a mperate zone, may succumb to exposure to the sun, the following example illustrates. In a laboratory the north of England, in which monkeys were kept a glass house, on more than one occasion during the mmer months several animals died under the symp- ms of heat stroke, showing an ante-mortem rectal mperature of 43.3° C. (110° F.), which still rose ter death. The painting of the glass roof with a ite wash reduced the inside temperature of the imal house and prevented death.

A consideration of the foregoing observations makes evident that exposure to the direct sun's rays caused ch an increase in body temperature that the animals ally succumbed to hyperpyrexia. In every case ani- ls of dark colour died more quickly than those with ht fur, on account of the greater absorption of heat. The dark skin of most of the aboriginal races in the pics, from the above point of view, would appear be a disadvantage and the explanation that dark in affords protection against the effects of the sun rely by insulating the body against the deep pene- tion of harmful rays must be modified.

Attempts to elucidate the rôle played by the pig- nt in a protective sense are not lacking in the litera- e. Eijkman (1895), in Batavia, covered the bulbs two thermometers with pieces of white and coloured man skin and placed the thermometers in the sun. noticed that the brown skin caused a higher rise the mercury (50.1° C.) than the white skin 7.5° C.).

Aron (1911) and Gibbs (1912), in the Philippines, perimenting with live skin, exposed white and col- red persons to the sun and recorded the skin tem- ratures of various parts of the body by means of a rmocouple. Their results were somewhat incon- nt; the skin temperature invariably rose after a time to from three to four degrees above normal. Whilst Gibbs found temperatures distinctly higher for the dark skin, Aron noted that the white skin was always hotter than the brown, and that after prolonged exposure the temperature of the brown skin showed a more distinct fall. "It may be said," as Freer (1912) remarks in summarizing the results of both investigators, "that as regards rise in temperature on exposure to the sun, the white and brown skin (Filippino) are about equal, with a slight factor in favour of the white, but that in regard to the very dark skinned negro the temperature on exposure reaches a decidedly higher point than it does with either of the others." In its physiological action, on the other hand, the dark skin is superior to the white skin. It absorbs a greater quantity of heat rays, warms up more quickly and reaches the point where perspiration commences earlier and the evaporation of the sweat causes heat loss and consequently affects the cooling of the body.

A consideration of the foregoing experiments and observations upon the effects of exposure to the sun suggests that any ill-effects are due not to light but to heat. These experiments, however, only take into consideration those effects known as sun stroke or heat stroke, and it is, moreover, an almost impossible task in such experiments to study the physiological action of the other rays with the entire exclusion of heat rays.

The effect of sunlight on living organisms has formed the subject of many publications and many opinions have been put forward which are not founded upon facts but are only wild speculations. Woodruff (1905), for example, wrote an extensive monograph on the effects of tropical light on the white man, and his conclusions have been widely quoted in the literature. He contended that the ultra-violet rays of the tropical sun are inimical to white settlement, but, unfortunately, he based many of his arguments on false premises, and many of his statements were merely expressions of personal opinion. As a glaring example, the following sentence may be quoted: "The southern hemisphere, except the tip of Patagonia, is north of 45° and therefore unfit for blondes" (he assumes that a blonde race cannot live nearer to the equator than 50°) and "even in New Zealand and Australia the native white families are already dying out or kept alive by constant new importation from home." He assumes, further, that in New Zealand there is ample evidence of the physical decay of the white population. In view of such statements, entirely without foundation, it is difficult to consider any of his conclusions seriously.

Effects of Heat and Humidity on the Animal Organism.

In all warm-blooded animals the temperature of the body under normal physiological conditions only varies slightly. This temperature is maintained by two processes—heat production and heat loss. The former is brought about by chemical processes, the combustion of food material inside the body, the latter by physical means, namely, radiation and convection and evaporation of sweat. In the clothed human being the heat production plays a much less important part in regulation of temperature than the heat loss by physical means and it is evident that the extent to which these physical means operate, must depend on the surroundings. Whereas in a cold climate heat loss takes place mainly by radiation and convection from the body, in a hot climate, where the air temperature often approaches or even exceeds that of the body, the heat loss through radiation can only be very small or nil and heat is mainly lost by evaporation of sweat from the skin.

It was of great interest to inquire into the physiological reaction of the animal body to increased outer temperature and a great deal of experimental work has been done in this direction. Attention has been paid to the body temperature and the metabolism in conjunction with the calorific value of the food, but a great deal of this work has been carried out in temperate climates under artificial conditions and comparatively few observations have been made actually in the tropics.

(1) Regulation of Body Temperature Under Artificial Conditions.

Blagden and Fordyce (1775) noticed that their mouth temperatures did not rise above normal when remaining for fifteen minutes in a dry room heated to a temperature of 115° C. to 126.7° C., although the heat was sufficient to cook a beef steak. Exposure for the same length of time, however, in a moist room heated to 54.4° C. caused the body temperature to rise to 37.8° C.. In recent times Haldane (1905) carried out his classical experiments on the effect of humid heat. His observations were made on human beings, both at rest and at work, in an artificially heated chamber, as well as underground in deep mines, in still air or exposed to artificial draughts. He concluded that the temperature of the human organism exposed to humid heat begins to rise after a period varying according to the individual and the conditions and then continues to do so. The rise in body temperature corresponds with the reading of the wet bulb temperature and is practically independent of the dry bulb temperature. During rest in still air, wet bulb temperature of about 31.1° C. (88° F.) could be borne without any abnormal rise in rectal temperature, but when the thermometer rose above that temperature the rectal temperature immediately commenced to rise, which rise was accompanied by an increase in the pulse rate, profuse sweating and dyspnœa, until finally exhaustion set in. During muscular exercise in still air this increase in body temperature commenced at a much lower wet bulb (27° C., or 80.6° F.), whilst in moving air much higher wet bulb temperatures were required to produce the same effect.

These experiments were continued and amplified in Haldane's laboratory by Harvey Sutton (1908), who studied the changes in the gaseous metabolism of the body when exposed to humid heat. He observed a large increase in the metabolism, running parallel to the rise in body temperature; in fact, analogous conditions to those existent in fever. He concluded that "all experiments point to the fact that once the balance of the mechanism of heat regulation in the human body has been definitely upset by high external temperatures, combined with almost total abolition of heat loss in evaporation, a vicious circle is established. The internal temperature rises and as a result the oxidation processes—and therefore the
production of heat also increases—so that the bo
temperature rises still further, and so on. Once t
ball has been set rolling, nothing seems to check
progress, and it slowly but surely gathers speed. T
rectal temperature not only continues to rise, wh
the external temperature still remains constant, l
the rise gradually increases in rapidity as if mom
tum were being gathered."

Conditions similar to those under which the
periments of Haldane and Harvey Sutton were c
ducted, may, according to Pembrey (1913), give r
to heat stroke. He analysed the history of a la
number of cases of heat stroke which had occur
amongst British troops in India, and came to the c
clusion that heat stroke is brought about by a fail
of the mechanism which regulates the body tempe
ture, after prolonged exposure to excessive moist h
In an excessively hot and moist atmosphere the cool
effect of the evaporating sweat is insufficient to p
vent the body temperatures from rising, and a p
longed exposure to these unfavourable circumstan
leads to a gradual rise in body temperature and u
mately to heat stroke.

Observations on the influence of wind and draug
on the body bring additional evidence to show t
with high external temperature, the loss of heat
to evaporation of sweat is the most important fa
in regulating the body temperature. As far back
1883 Herman suggested that the ill-effects due to
ventilation and crowded rooms were caused by h
stagnation. This view was confirmed experiment
by Heyman, Paul and Ercklentz (1905) and later
by Hill, Flack, Rowlands and Walker (1913).
and his colleagues confined individuals in a small
perimental chamber until the carbonic acid con
rose from 1% to 1.5% in one instance
from 3% to 4% in another. The subj
experienced discomfort at a wet bulb t
perature of 27.7° to 28.4° C. (82° to 85°
and this discomfort was considerably allayed w
the air in the chamber was moved by a fan. No re
however, was experienced when fresh air was breat
through mouthpiece and tube passing through the
of the chamber. Subjects outside the chamber
breathed the chamber air suffered no discomfort,
proving that the discomfort was caused not by the
creased carbon dioxide of the air in the chamber,
by the heat stagnation, following the failure of e
oration of sweat.

The part played by the evaporating perspirati
illustrated in Zuntz and Tendlau's observations
the body temperature of a man whose skin was de
of sweat glands. The exposure to the summer
of a temperate climate caused his temperatur
rise to 39° C. (102.2° F.) and a slight amour
manual work produced the same effect. He was,
ever, able to find a substitute for the missing
tion by frequently soaking his shirt in water.

Such a condition as described above can be
ficially produced by immersion in a hot water
when the evaporation from the skin is prevented
the effects of perspiring are eliminated. Hill
Flack (1909) studied the pulse rate, blood pres
body temperature, breathing volume and alveolar

ns of man in a hot bath. They found that immer-
n up to the neck in hot water (40.5° to 43.3° C.,
105° to 110° F.) for fifteen to thirty minutes caused
increase in the body temperature to 39.1° to 40.3°
(102.5° to 104.6° F.). The pulse rate and respira-
n rate and volume rose and the blood pressure was
ered. In the alveolar air a notable fall in car-
ic acid tension and a corresponding rise in oxygen
sion were observed, caused by the washing-out
ct of the increased breathing.

The foregoing observations make it clear that the
in difference between temperature regulation in
tropics and in a temperate climate lies in the
ater activity of the sweat glands, and the evapora-
n of the increased amount of sweat plays a more
portant part in the cooling of the body. It is a
mmon experience in the tropics that the quantity
water secreted in the urine is greatly diminished
ring hot weather, in spite of the larger intake of
id; the balance of the water leaving the body by
y of the skin and the lungs is considerably larger.

The establishment of an equilibrium between the
ter secreted by the kidneys and that secreted by
sweat glands is probably of importance in the
cess of acclimatization. Inhabitants of the tropics
w only too well the discomfort caused by the fre-
nt necessity of micturition during a sudden cold
ll, even at times when the temperature is well
ve that which would be regarded as comfortable
l even warm in a temperate climate. Moreover,
feeling of subjective discomfort on such occasions
ery marked and this sensitiveness to cold has given
to the popular belief that the blood of dwellers
the tropics is thinner than that of a person living
a temperate climate.

Changes in the Physiology of the White Man Living Under Tropical Conditions.

he tradition that the white man cannot flourish
tropical climes has given rise to a great deal of
troversy and the possibility of an acclimatization
constantly occupied the attention of authorities
rested in the development of the tropics. It has
n propounded by several observers with experience
life in tropical countries that, apart from diseases
uliar to the tropics, climate *per se* comprising
t, humidity and light make it impossible for a
ite race to settle and thrive. Attempts have there-
e been made to study the physiology of the white
n living in the tropics, in order to ascertain whether
nges have actually taken place, and for comparison
investigations have been extended to native races.
results so far are by no means complete and a de-
d answer is still to seek.

ittle reflection is needed to appreciate the diffi-
ties which stand in the way of a practical solu-
n of the question. Tropical diseases have up to
ent times been very prevalent in most parts and
e been a large factor in preventing settlement by
hite race. The pioneer work of Manson and Ross
the rôle of insect carriers in such diseases as filaria
l malaria has laid down new lines for the investiga-
n of other tropical complaints. The practical ap-
ation of the results has led to increased public health activities and has thus created a new era in the permanent settlement of the tropics by inhabitants of European descent. Moreover, the tropics, with only few exceptions, such as the South American Republics, have only recently been settled; a second and third generation is rare, and it is impossible to obtain and select subjects in sufficient numbers for carrying out observations which would yield results which could not be attacked on the plea of insufficient time of observation. The conditions of life in general also, for example, housing, ventilation and food, are so different that the difficulty of obtaining figures suitable for a comparison of physiological functions is greatly increased and comparative standards in many respects are lacking.

A critical review of the literature on acclimatization brings to light the fact that nearly all observations have been made on Europeans who have resided in the tropics for a comparatively short time. The majority were men chosen for service in the tropics on account of their physical fitness and few of them could boast of an uninterrupted residence in the tropics for more than a few years at most.

As an example, in the work of the American observers in the Philippines, the figures relating to Europeans were obtained with male subjects only, and furthermore cannot be accepted, excepting on the supposition that changes due to climatic influences become established within a comparatively short time. The same criticism may be applied to experiments on metabolism carried out by Eijkman in Java, whose subjects had resided in the tropics for from four and a half to fifteen years, and out of nineteen Europeans only one could show a continuous residence of fifteen years. Results such as those of Rattray, Wick, Schilling and many others are the outcome of observations on one or a few subjects only, collected during a flying visit to the tropics.

Investigations on aboriginal races, although interesting from a comparative point of view, do not help to solve the problem, on account of the different mode of living, customs and personal habits.

(*a*) *Body Temperature in the Tropics.*—The fact that the external temperature in the tropics is considerably higher than in a temperate climate suggested a raised body temperature. On account of the ease with which the body temperature can be taken, it is not surprising that the literature contains records of numerous observations, many collected during a sea voyage between Europe and the tropics, others on Europeans and native races living in the tropics.

John Davy, in 1839, published a number of observations made upon the mouth temperature of seven healthy men during a voyage from England to Ceylon, and he concluded that the temperature of a European increased whilst passing from a temperate to a warm climate and that, in addition, the body temperature of residents in the tropics is slightly raised above normal. He amplified his work during a residence of three years in Barbados and stated that his own temperature was higher by 0.5° C. (0.9° F.) when compared with his body temperature in England. Many others, including Reynaud and Blossville, Rattray, Brown-Séquard, Jousset, Maurel and others (referred to by Pembrey, 1898) confirmed this slight rise (less than 0.55° C., or 1° F.), which was more pronounced during the first few weeks of residence in the torrid zone, that is, during the time of acclimatization. Crombie (see Pembrey, 1898) recorded the results of 1,288 observations upon his own mouth temperature in Bengal and found it slightly higher (namely, 0.23° C., or 0.7° F.) than in England. Neuhauss (1893), who, during a voyage round the world, observed his own rectal temperatures, found the following differences (see Table II.).

TABLE II.

Temperature of Air.		6 a.m.	12 noon.	10 p.m.	6 p.m.	Remarks.	
Temperate Zone.							
Minimum.	Maximum.						
11.5° C.	19.1° C.	36.6° C.	36.9° C.	36.7° C.	37.1° C.	Temperature in rectum	Mean of 20 days
(51.7° F.)	(56.5° F.)	(97.9° F.)	(98.5° F.)	(98.2° F.)	(98.8° F.)		
		55	55	56	62	Pulse	
Tropical Zone.							
Minimum.	Maximum.						
28.8° C.	26.6° C.	36.9° C.	37.3° C.	37.1° C.	37.3° C.	Temperature in rectum	Mean of 20 days
(75.0° F.)	(79.9° F.)	(98.5° F.)	(99.2° F.)	(98.8° F.)	(99.2° F.)		
		60	68	64	72	Pulse	

On the other hand, many observers have denied that there is any marked difference in the body temperature; amongst others were Thornly (1878) and Furnell (1878) and more recently Wick (1910), who could not observe any alteration in his body temperature during the passage from a temperate zone to the tropics.

Chamberlain (1911), as the result of 3,000 mouth temperatures, taken at quarterly intervals upon 600 healthy American soldiers living in the Philippines, arrived at a similar conclusion. According to him, the temperature of American soldiers doing duty in the Philippines showed no appreciable variation for season or for complexion type; it averaged 37° C. (98.7° F.) and this average differed little, if at all, from the mean normal temperature for white men living in the United States. In Plehn's (1898) opinion there is a slight rise in temperature during acclimatization, but after continued residence this rise disappears.

The body temperature of dark-skinned native races in the tropics does not differ appreciably from that of Europeans. A. Jousset (1884) found that the average temperature of Hindoos, Chinese and negroes was 37.8° C. (100° F.), whereas that of Europeans under similar conditions was 37.87° C. (100.1° F.). Eijkman (1895) in Batavia compared the axillary temperature of Malays and Europeans and found that the Malays had a slightly lower temperature (36.85° C., or 98.3° F.) when compared with Europeans (37° C., or 99° F.).

Young (1915) in a recent paper on this subject recorded a number of observations taken during the hot season in North Queensland. He pointed out that it is fallacious to speak of a normal mean body temperature, as that of a healthy person, even at rest in a cool climate, varies considerably during the twenty-four hours,[2] and considered it more rational to e
ploy as standard the range of body temperature wh
has been observed in healthy individuals. He co
cluded that:—

> 1. The temperature of the mouth of Europeans liv
> in the tropics is often considerably lower than that of t
> rectum and that this difference is generally much m
> marked after exercise, just as in temperate climates. T
> temperature of the mouth is thus not reliable as
> measure of the body temperature.
>
> 2. During complete rest the rectal temperature did
> show any marked variations from the limits of tempe
> ture observed in Europe.
>
> 3. A considerable rise in the rectal temperature
> produced by slight muscular work and this was usu
> maintained for some time after the work had ceased.

These observations make it clear that the discr
ancies in the records quoted above are in all pro
bility partly due to the mode in which the tempe
tures were taken and partly to individual and d
variations.

At rest the body temperature in the tropics does
vary from that in a temperate climate, but with e
cise the temperature rises more quickly and su
quently decreases more slowly than in a tempe
zone. A good example of this is quoted by Young
respect to one of his subjects, who was in the habi
taking exercise in the early morning; during a pe
of eighteen days his average rectal temperature
8 a.m. was 37.9° C. (100.3° F.). On three occas
on which the exercise was omitted the rectal temp
ture at the same time was only 37.5° (99.6° F.).

(b) *Rate of Respiration.*—A comparison of the
spiration rate of tropical inhabitants with that fo
in Europe has yielded conflicting evidence. Acc
ing to Rattray (1870) the total volume of air exp
was about 7% less than in a temperate climate,
he attributed this to a decreased rate of respirat
since spirometer measurements showed that the l
capacity was increased. These observations, mad
a small number of subjects, were not confirmed
Jousset and by Plehn, who, on the contrary, foun
increase in the respiration rate. Chamberlain (1
made observations on 608 American soldiers in

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[2] Benedict and Carpenter (Carnegie Institution monographs, No.
1910), writing on this subject, state that "the idea of constancy in
temperature has become so generally accepted that it is commonly be
that the body remains at the temperature of 98.6° F. or 37° C. w
material change, other than that produced by disease. This impress
so firmly fixed that one finds to-day on all clinical thermometers a s
mark opposite this temperature, to indicate what is supposed to
normal temperature. It is somewhat difficult to place the exact
of this mark being selected, and it may be looked upon as more or l
a thermometric fetish, which has been worshipped by long-continued u

ilippines. He found the average to be 19.3, which much higher than the figure usually accepted as rmal for Europeans in Europe, namely, 17 to 18. may be mentioned here that Osborne (1910) carried : observations during the summer months in Vic- ia (Australia), and found that with a high outer nperature (37.7° C., or 100° F.) the pulmonary ntilation was increased.

n consideration of the fact that the human body es a certain amount of water in the expired air l consequently heat due to the evaporation of the ter, it might be expected that the body would make of this means for cooling purposes and an in- ased respiration would be the outcome.

c) *Blood Pressure.*—Estimations of the blood pres- e in the tropics have been made by a number of ervers with contradictory results. Musgrave and son (1910) in Manila examined 97 Americans, 10 ers of charity and 40 Filipinos. They graded the mer two groups according to their length of tropi- residence and found a decided decrease in the od pressure, corresponding to the length of resi- nce in a hot climate and suggested that the lower od pressure might be due to a lowered peripheral istance, brought about either by a decrease in the omotor tone or by splanchnic influences. Cham- lain (1911) took the blood pressure of 992 Ameri- soldiers in the Philippines and made 5,368 obser- ions and concluded that "the average blood pres- e of 115 to 118 millimetres found in these large lies of men differed little, if any, from the ac- ted standard among males of the same age in a nperate zone when the five inch armlet is used."

reinl and Priestley (1914) estimated the blood ssure of North Queensland school children and con- led from 573 observations that the climate as such no marked influence on the blood pressure in ldren.

heoretically a permanent change in the blood pres- e in the tropics should not be anticipated, as a nd heart and sound arteries are adaptable to any nge. Only temporary variations are observed, h as a rise in blood pressure on exertion or a lower- due to venous hyperæmia of the skin, similar to t produced by a hot bath, but both would only be nescent and not peculiar to tropical life.

d) *Blood Conditions of Europeans in the Tropics.* he existence of tropical anæmia has for a long e been regarded as an established fact and most he early text-books on tropical medicine speak of anæmia due to climatic influences only. There is doubt that the greater proportion of the cases in time before microscopical examination became eral were in all probability caused by malaria and kworm (anchylostomiasis). The skin of the healthy opean inhabiting a tropical climate appears to the comer pale and sallow, the degree of the sallow- s depending on many factors, especially complexion skin texture. The unprotected skin of individuals red or fair hair is invariably more sallow and ap- rs more anæmic for the same reason that it has, account of the lack of pigment, a lesser defensive er against the action of the sun's rays. The paleness of the skin has naturally given rise to the conception that there exists a tropical anæmia and that "thinness and poorness" of blood is a natural sequence of prolonged residence in the tropics. It is not unexpected that the advent of accurate microscopical methods has led to an investigation of blood conditions of Europeans in the tropics and the results of these investigations have been rather surprising.

Marestang (1889), van der Scheer (1890) and Eijkman (1891) examined the blood of Europeans living in the Dutch East Indies without finding any marked differences when compared with figures obtained for Europe. Glogner (1892) in Sumatra and Plehn (1892) in the Cameroons carried out similar investigations with identical results. These observations, however, are not entirely conclusive, since they were based on a comparatively small number of estimations.

Work of a similar nature was carried out by the Americans in the Philippines. Wickline (1908) examined the blood of about 70 American soldiers, after a varying period of residence in the Philippines. The first examination was made three months after their arrival; it was repeated after the lapse of three months and twice again after an interval of approximately eight months. He discovered a gradual decrease in the percentages of hæmoglobin from 94 to 83 and a regular rise in the number of erythrocytes from 4.9 to 5.3 millions. Chamberlain (1911), following up Wickline's work, performed 1,718 red cell counts and 1,433 hæmoglobin estimations on 702 soldiers and concluded that "the red cell counts, averaging 5.2 millions, rarely falling below 4.5, do not differ from the normal at present recognized for healthy young men in a temperate zone." The hæmoglobin figures are perhaps a little low, but not sufficient to indicate a definite anæmia.

Cuthbert (1911) collected similar observations from 21 healthy soldiers of European descent on the West Coast of Africa with a similar result. Wickline's and Chamberlain's figures were obtained from healthy subjects, especially chosen for tropical service, and after a comparatively short residence in the tropics (two years) and are open to the objections already mentioned.

Breinl and Priestley (1914) made observations on apparently healthy school children in North Queensland of ages ranging between seven and fifteen years, most of whom were born and had lived all their life in North Queensland. Five hundred and seventy-four blood counts were performed on 305 boys and 269 girls and the hæmoglobin content of the blood was estimated by the Fleischl-Miescher method.

They concluded from their investigations that there is no striking difference in the number of erythrocytes and the colour index in North Queensland children when compared with averages obtained in children of a temperature climate. The number of white blood corpuscles (leucocytes), according to Chamberlain (1911), also to Breinl and Priestley (1914), is slightly higher when compared with that generally accepted as the standard for a temperate climate.

Differential counts, which estimate the percentage of the various types of leucocytes, showed, according to these observers, a distinct alteration. The proportion of the polymorphonuclear neutrophile leucocytes appeared to be decreased to 56.1% (Chamberlain and Vedder, 1911) and 56.8% (Breinl and Priestley); 65% to 70% is generally accepted as average. The percentage of the eosinophile leucocytes was distinctly increased.

Chamberlain and Vedder (1911) studied the blood conditions of American soldiers and natives in the Philippines and came to the conclusion that the Arneth blood picture of the soldiers showed a slight "shift to the left," that of the Filipinos a much more marked shift, which means that the nuclear condition of the polymorphonuclear neutrophile leucocytes in respect to the numbers of nuclear fragments was altered when compared with those of healthy Europeans living in a temperate climate; the number of cells with a smaller number of fragments (one to two) was considerably increased. Breinl and Priestley (1914) carried out analogous observations on North Queensland school children and found that similar conditions prevailed and that the blood picture resembled closely that of the Filipinos. The authors concluded that the "shift to the left" was due to the effect of a tropical climate upon the white race living in the tropics.

For comparison a number of Arneth counts on apparently healthy native children in the Northern Territory were performed and their "Arneth index" corresponded closely to that of North Queensland school children.

The significance of the altered Arneth index is uncertain and, according to Breinl and Priestley (1914), the presence of a large number of neutrophile leucocytes belonging to class one (possessing a single nucleus) "indicates a greater activity of the bone marrow, but does not necessarily imply that the resistance of the organism is lowered" (to disease) "in any way."

A few observations on the specific gravity of blood were made by Eijkman (1896) in Java and by Breinl and Priestley (unpublished) in Townsville. The results did not show any marked deviation from the average specific gravity of the blood considered normal for a temperate climate, and, when considered in conjunction with the previously mentioned blood work, proves that there is in general no evidence of an anæmia in the tropics due to climatic influences only. The popular belief of the "thinness of the blood" after prolonged residence in the tropics is, apart from anæmia due to disease, from a scientific point of view only a myth.

(e) Metabolism in the Tropics.—In a cold climate, as has been stated previously, the temperature equilibrium of man is maintained mainly by regulation of the heat loss through radiation, convection and evaporation (termed by Rubner physical heat regulation), whilst changes in the heat production (Rubner's chemical heat regulation) take place only to a small extent. In fact, Rubner has said that a man feels comfortably warm only when the chemical regulation of his heat balance is completely eliminated. In a cool climate chemical heat regulation can only be spoken of in the sense that the stimulating eff of cold on the skin causes reflex innervation of t muscles, resulting in their movement or increased to which brings about an increase in the production heat, *i.e.*, the increased metabolism is really due to t muscular action and not to cold *per se*.

The question naturally arose whether the chemi heat regulation plays any part in maintaining t equilibrium in the tropics where the external tempe ture is high; in other words, whether the body sponds to these different conditions by a reduced co bustion of food material. This problem has been tacked in two ways: first, by a comparison of calorific value of the food actually katabolized Europeans living in the tropics, with the average va found in temperate climates, and, secondly, by a co parison of the total metabolism in both parts of world, as determined by the respiratory gas exchan that is, the oxygen absorbed and the carbon diox eliminated, the experiments being carried out oth wise under exactly the same conditions.

The most important work in the first directio that of Eijkman (1893), who investigated the foo seven Europeans living in the Dutch Indies. His periments, lasting for several days, were carried as follows: At each meal each person under obse tion took a second portion of each dish, similar quantity, as judged by the eye, to that which he sumed, and these duplicate meals were collected each day and the protein, fat, carbohydrate, etc. them estimated. At the same time the fæces were lected and analysed to determine the quantity of f actually absorbed.

Allowing for the loss in the fæces, he obtained following figures for the average constituents of food actually utilized:—

Protein	88.2 grms.
Fat	79.1 grms
Carbohydrate	256.4 grms
Ash	17.5 grms
Alcohol	28.5 grms

From the results he calculated that for a man we ing from 65 to 70 kilograms the heat production f the food amounted to 2,400 to 2,500 calories, a fi which does not differ from that given by Rubner men doing a similar class of work in Europe, nam 2,445 calories. The excretion of nitrogen in the u and fæces showed that, on the whole, his subjects m tained nitrogen equilibrium during the experime

Eijkman concluded from these experiments there was no evidence that chemical heat regula played any significant part in the thermo-equilib of inhabitants of the tropics.

A different conclusion was arrived at by R (1900), who published the results of observa upon himself extending over a few days, compa the calorific value of his food in Europe and du a short residence in Brazil. In Europe the heat of his daily food in two experiments was 3,527 3,514 calories respectively. In Brazil, however calorific value of his food was much less, being 2,812, 1,920 and 1,948 calories respectively in series of observations.

Ranke's experiments have been criticized adversely Glogner (1909), who conducted similar determina- ns upon himself at different times during his resi- nce in Sumatra and Padang and again after his re- n to Europe. He stated that loss of appetite is ommon experience during the first period of resi- nce in the tropics and attributes the lower values ained by Ranke to the fact that the latter had only n a few months in the tropics when the experi- nts were carried out.

Glogner's experiments, conducted after a six years' idence, and lasting for fourteen days, showed the rage energy value of his daily food to be 2,118 aries, or 28.8 calories per kilogram of body weight day. A similar experiment was performed in rope fifteen years later—five years after his de- rture from the tropics—and then the daily average s found to be 2,038 calories, or 25.5 calories per ogram of body weight. It is doubtful, however, ether any value can be placed on these observa- ns since the first series was made when the subject s 32 years old and weighed 71.1 kilograms and the ies for comparison when the subject was 47 years and weighed 80.3 kilograms.

xperiments were carried out also upon themselves Schilling and Jaffé (1909) during a visit to West rica and the results were compared with observa- ns made in Berlin, both before and after their rney. There were no appreciable differences be- en the heat value of their food in both parts of world, the average being 2,863 and 2,953 calories day for Jaffé and 2,953 and 3,021 calories per day Schilling in Europe and Africa respectively. In h places nitrogen equilibrium was approximately intained on about 17 grammes of nitrogen per day.

n a similar way the nutritive value of the food of ive races in the tropics has been estimated for nparison with that of white people. Eijkman 93) examined the food of five Malays in a similar nner to that employed in his experiments quoted ve and found the following average for the l actually katabolized, after allowing for the ma- al lost in the fæces:—

Protein	59.9 grammes
Fat	25.0 grammes
Carbohydrate	462.0 grammes
Ash	13.2 grammes

heat value of the food was about 2,349 calories an average body weight of 50 kilograms, *i.e.*, a re slightly higher per kilogram of body weight n that given by Rubner for men in Europe. The unt of unabsorbed matter in the fæces was much ater in the Malays than in the Europeans, prob- on account of the large preponderance of vege- e food in their diet.

n extensive inquiry has been made by McCay 12) in India into the food of various native races. Bengalis he found that the calorific value of the l was higher (3,196 calories) and the nitrogen er than that of Europeans. A study of the diet nutrition of the Filipinos was made by Aron (1909) and the average composition of the daily allowance in the Manila native prisons was given as:

Protein	55.9 grammes
Fat	27 grammes
Carbohydrate	510 grammes
Calories	2,646

An estimate of the calorific value of the food eaten by a Filipino living under normal conditions corresponded to from 2,500 to 2,600 calories and when allowances were made for the smaller body weight of Filipinos (50 to 55 kilos.) this value corresponded to the requirements of a working-man in Europe performing moderately hard labour.

Recently Campbell (1917) examined the food of several native students (Chinese, Tamil, Malay and Brahmin) and obtained values ranging from 1,502 to 2,492 calories per day.

The results of these investigations into the food value in the tropics make it clear that in general the requirements in calories, either of white men or coloured natives, do not differ appreciably from European standards. The experiments quoted above indicate that the amount of heat produced by the combustion of food is not any less in the tropics than in a temperate climate and that nature does not have recourse to a reduced metabolism to regulate body temperature.

The energy involved in the total process of oxidation (heat production) taking place in the animal body, may be measured either by the actual heat value of the food digested (calorific value of the food), or again by the quantity of oxygen used up and carbon dioxide and water produced (the respiratory exchange), which measures the end products of this oxidation.

If metabolism would play any appreciable part in controlling the body temperature in the tropics, it would find its expression in a reduced oxygen absorption and carbon dioxide production.

Experiments upon the influence of high external temperature and humidity upon the respiratory exchange have been carried out from this point of view under artificial conditions upon man and animals, and on man in the tropics.

The general results of these experiments show that with cold-blooded animals the oxygen absorbed and carbon dioxide eliminated are directly proportional to the external temperature, in other words, there is no heat regulation and the body temperature is that of the surroundings. With warm-blooded animals, on the other hand, the organism regulates its heat to a more or less extent. With the monotreme, *Ornithorhynchus,* the mechanism is almost entirely chemical, thus with increasing external temperature the metabolism decreases until a temperature of 32° C. (89.6° F.) is reached, the body temperature remaining throughout almost constant; above this the animal's temperature rises, thus indicating that the regulatory mechanism is failing, until finally with increasing outer temperatures the animal behaves like a cold-blooded animal.

In the rabbit the same is observed, but to a less degree, because the mechanism is complicated by loss of heat by physical means.

In man the elimination of carbon dioxide is not affected by rising external temperature in a constant manner. In some experiments carried out under artificial conditions it has been noticed that with rising temperature the carbon dioxide sinks in quantity at a temperature of about 15° C. (59° F.), reaches its minimum between 20° C. (68° F.) and 25° C. (77° F.), and then rises slightly. In other experiments, however, no such change has been observed. Generally speaking all that can be said is that there appears to be an ill-defined zone of temperature in which the metabolism is at a minimum. When the external temperature and humidity are so high that the physical regulation fails and a rise in body temperature results, this rise is accompanied by an increased metabolism, still further increasing with continued rise of body temperature, until dangerous conditions are reached, as already stated.

A study of the gaseous metabolism under actual tropical conditions was made by Eijkman in Java. By means of the Zuntz-Geppert method he determined the quantity of oxygen consumed and of carbon dioxide eliminated during rest by 11 Europeans and 12 Malays. He obtained the following averages as the result of 48 experiments on Malays and 37 experiments on Europeans (See Table 3). The numbers are calculated to a body weight of 64 kilos.

TABLE III.

	Oxygen Absorbed per minute	Respiratory Quotient.
Europeans in Java	245.7 ..	0.791
Malays in Java..	251.5 ..	0.880
Europeans in Europe	250.3 ..	0.775

Eijkman interpreted these results as confirmatory of his other experiments already quoted, namely, that the heat production by the body in the tropics is not less than in a temperate climate, and that therefore change in heat production plays an insignificant part in the regulation of temperature. He attributes the higher respiratory quotient of the Malays to the larger proportion of carbohydrates in their diet.

In reviewing these researches on the metabolism in the tropics it is necessary, before drawing any conclusions, to consider the limitations of metabolic experiments in general. Contradictory results may be accounted for in some measure by different food, habits and customs in various countries in which the experiments have been carried out, and by individual variations. Moreover, up to the present no definite standard has been acknowledged.

A large number of observations upon metabolism during complete rest, which is termed basal metabolism, have been carried out during several years in the Nutrition Laboratory of the Carnegie Institute in the United States by Benedict and his co-workers. Subjects included men and women of various ages, athletes, vegetarians, etc. The general conclusions drawn from these experiments have been embodied in a paper by Benedict (1915) upon the factors affecting basal metabolism, in which he pointed out that a much larger number of factors enter into this question than has been hitherto recognized. Although
body weight plays an important part there is no dir
relationship between the body weight and the to
heat production. Similarly with body surface,
general belief that heat production is determined
body surface is not strictly accurate; a careful ana-
sis of metabolism measurements shows that the h
output is not proportional to the body surface. Ot
factors are the proportion of inert fat and act
protoplasmic tissue in the body composition, and
the height and age. Finally there are large variati
from day to day in the same individual. Summ
up his conclusion Benedict says:—

> It is clear that the basal metabolism of an indivi
> is a function first of the total mass of active protoplas
> tissue and second of the stimulus to cellular activit
> the time the measurement of the metabolism is m
> Apparently at present no law can be laid down that
> cover both of these important variables in the b
> metabolism of an individual.

In the light of this work it is at once seen t
units for comparing the metabolism are still only
the making, and a comparison is only possible of
averages of experiments on large numbers of
dividuals, extended over a long period of time, s
to eliminate changes which might be due to the t
porary ascendency of any one factor. It is obvi
therefore, that researches which have been m
hitherto on total metabolism have not been o
sufficiently large scale to justify any definite
clusion and probably the discrepancies in the res
of different experimenters may be accounted fo
this way.

The researches into the total metabolism and
production in man have so far not revealed
changes which might be attributed to the influenc
climatic conditions. It has, however, repeatedly
pointed out that the dietary of the majority of
aboriginal races in the tropics contains a relati
small proportion of protein. This fact has natu
led to the presumption that dwellers in the tr
require a less amount of protein in their food.
tein differs from the other food constituents in
respect that it is utilized by the organism in
directions, namely, for producing energy and b
ing up tissue. It is, therefore, not unexpected
the protein requirements of tropical inhabitants
been studied in detail.

Eijkman (1893) in Java found that Malays
sumed 73.3 grammes of protein per day, of w
about 56 grammes were actually metabolized.
amount far below the standard usually accepte
Europe (100 grammes). An extensive series of
servations on the protein content of the dietar
native races in India has been carried out by M
(1912), who investigated its bearing upon
physique and general efficiency of his subjects. I
opinion the small quantity of protein generally
sumed by the natives was not the result of wa
desire but of inability to procure a larger qua
and he convinced himself that most natives w
eat more if they could obtain it. He concluded
those races with a higher level of protein interch
were generally more robust, energetic and
manly. In the same way the daily food of Fil
prisoners, according to Aron (1909, contained
75 grammes of protein,

A much higher quantity of protein was utilized, ording to Eijkman,by Europeans living in Java. found that the food of his experimental subjects tained 99.6 grammes of protein, of which 88.2 mmes were actually absorbed, which amount cor- ponds to the normal protein requirements in rope. Other observers who examined their food ring a visit to the tropical zone, confirmed this. us Ranke, during his voyage to Brazil, found very le change in the protein of his food, and Jaffé Schilling found that nitrogen equilibrium was intained on the same amount of protein in Europe in West Africa.

nfortunately the whole question of the protein uirement of man is still unsolved. Atwater's ndard of 125 grammes of protein a day Chittenden's standard of about 60 grammes are h accepted by various workers, and recent experi- nts of Hindhede have shown that nitrogen equili- um can easily be maintained upon a much lower ount of protein, provided that the diet contains ficient calorific value. He himself maintained rogen equilibrium on 32 grammes of protein for days. The question is further complicated by the essity of accessory food products and their relation the different constituents of the food, about which are as yet in almost complete ignorance.

he protein metabolism has been further studied the examination of the various constituents the urine, since the final products of its radation are excreted in the urine. Eijk- n found that the urine of Europeans liv- in the East Indies did not differ appreciably m standards in Europe. He found the average ume for twenty-four hours as 1,442 c.cm., the spe- gravity 1.017, whilst the average nitrogen content 13.04 grammes. In the physiological text-books average for Europe is generally given as 1,200 to 0 c.cm., with a specific gravity of 1.015 to 1.025 a total nitrogen content of 14 to 18 grammes. He wed for 1.6 grammes of nitrogen lost in the sweat concluded therefore that an acclimatized Euro- n passed as much nitrogen in his urine as he did Europe.

ther observers, such as Wick, Ranke and Neu- ss, however, found that the urine is much more centrated. Observations in this respect, extending some time, have been made in Townsville by ng (1919). A number of urine samples ected during the hot months have been mined in this Institute and the average res were obtained for the daily urine of nty-five persons, some of whom were en- ed in manual labour and others followed a ntary occupation. The averages calculated are n in the table 4 together with European stan- ls:—

TABLE IV.

	In Townsville.	European Standard.
ntity..	782 c.cm.	1,500 c.cm.
ific Gravity..	1.025	1.015 to 1.020
l Nitrogen ..	10.4 grm.	16 grm.
m Chloride..	7.00 grm.	15 grm.
phates	1.73 grm.	2 to 3.5 grm.
zing Point ..	—0.935° to —2.259° C.	—0.87° to —2,71° C.

These observations reveal decided differences. The volume was much lower and the specific gravity higher. The total nitrogen, too, was smaller. The most striking difference lies in the quantity of sodium chloride, which may be accounted for by the increased quantity of sweat lost, which carries with it sodium chloride. Estimations of the amount of water lost from the skin during exercise in Townsville have yielded interesting figures. After a brisk walk of about seventy minutes with an external temperature of 24.4° C. (76° F.) wet bulb, as much as 1,100 grammes in weight have been lost. As the subjects of these experiments were weighed in their clothing this figure only represents the water which had actually evaporated. Samples of sweat carefully collected contained from 0.1 to 0.3 gramme of sodium chloride per 100 c.cm., and the cutaneous excretion would account for several grammes of sodium chloride in the above experiment. The nitrogen lost in the sweat can only be small and is almost negligible, since samples of sweat only contained 0.03 to 0.04 grammes per 100 c.cm.

The urine measured during the cold weather averaged a higher volume, 1,357 c.cm., a lower specific gravity 1.019, and an increased salt content, 9.44 grm. per day.

The total nitrogen in the urine in Northern Australia was decidedly below the European standard, even considering that a small amount (1 to 2 grammes per twenty-four hours) may leave the organism by way of the skin. There is thus an indication of a decrease in the amount of protein metabolized. Whether this is due to a smaller intake of food brought about by a want of appetite during the hot weather, so commonly observed, or whether other factors came into play must be left an open question.

(f) Effect of a Tropical Climate on the Nervous System.—In many of the writings on health and disease in the tropics attention has been drawn to the frequent occurrence of a mental condition resembling neurasthenia, of the same type as that found in temperate climates. It occurs mostly amongst Europeans, women and men, after a prolonged residence in the tropics, and is referred to in the literature as tropical neurasthenia. In its mildest form it manifests itself in a lability of the mental equilibrium, fits of depression alternate with states of exuberance; unwarranted irritability over trifling matters is hardly ever absent, leading to uncontrollable outbreaks of temper. It is associated with a loss of mental activity and power of concentration, lack of confidence and failing memory, all of which cause a decreased working capacity. The realization of this state and the futile attempts to overcome it by increased spurts of energy tend to exaggerate the trouble. This condition may be stationary for a long time, influencing the career of the sufferer, or may get steadily worse and lead to a condition termed by Plehn "tropical fury" (*Tropen Koller*), which often explains the committal of deeds of violence in an outburst of uncontrollable passion.

Amongst others Fales (1907) has drawn attention to the occurrence of neurasthenia amongst men and women after a residence of a year or more in the

Philippines, which in women is often associated with disturbance of menstruation and of the vasomotor system. In his opinion it is in most instances not directly attributable to parasitic invasions, but to climate only and forms one of the chief drawbacks to acclimatization. Woodruff made the same observation in the same locality, and attributed the condition entirely to the effects of tropical light.

In 1913 the Society of Tropical Medicine devoted a meeting to the discussion of this subject, at which the President, Sir Havelock Charles, delivered an introductory address on "Neurasthenia and its bearing on the decay of northern peoples in India." He discussed the occurrence of "Punjab head" in Bengal, which is characterized by shortness of temper, forgetfulness, sleeplessness and disinclination to work, etc., which corresponds to tropical neurasthenia. Similar "heads" occur throughout India and other parts of the tropics, and affect Europeans after having lived in the tropics for a considerable period without furlough. In a number of cases, according to Havelock Charles, tropical disease may be held primarily responsible for the condition, but in many instances he considers climate alone as the root of the evil. Since, "the constitution of the northern races is developed in temperate latitudes" he believes "that its powers are injuriously affected by the climatic conditions of the hot zone, and this must be attributed to damage done mainly to the nervous system by a hot and humid climate." Unfortunately his address and a great deal of the discussion which followed, were marred by statements which were merely expressions of personal opinions, collected during a shorter or longer residence in the tropics, and often coloured by prejudice; actual data in support of these opinions were sadly lacking.

Basil Price (1913), who for many years examined the causes of invaliding home of members of the Church Missionary Society, found that neurasthenic conditions were the cause of 25% of invalidity in most countries.

A perusal of the general literature on the tropics confirms the fact that a complaint similar to neurasthenia is very prevalent amongst Europeans who have emigrated to the tropics, but it is difficult to gauge how far climatic influences alone may be held responsible, or what part is played by the altered conditions and habits of tropical life. The novelty of the strange environment often leads to an increased output of energy and it is only after a time that the newcomer realizes his energy capacity under the new conditions and begins to husband his strength, but often too late to avoid paying the penalty.

It is, however, beyond doubt that the monotony and discomfort of life and climate, the lack of pleasure and excitement, the big distances from the centres of civilization and, in women especially, the confinement to the house during the hot hours of the day, all help towards producing a mental condition resembling neurasthenia.

(g) Clothing in the Tropics.—The degree of bodily comfort in the tropics, in the same way as in a cold climate, is governed by a number of factors, many of which may be modified artificially. In a cold climat
bodily comfort is attained by conservation of heat, i
a hot climate by the allowance of a maximum amou
of cooling and the clothing is a very important fact
in this respect.

The literature contains numerous accounts of e
periments and suggestions on the most suitable ki
of clothing for a tropical climate. The aboriginal i
habitants possess a dark pigmented skin and, theoreti
ally, therefore, a dark coloured garment, allowing
ample ventilation, would appear to be the ideal, sin
it would imitate nature. Practice, however, does n
bear out this assumption. It has been shown that
dark skin absorbs heat rays to a greater extent th
does the white skin; its temperature, therefore, ris
more quickly and the sweating mechanism is broug
into action earlier and the cooling due to evaporati
is more effective. A dark dress material absorbs he
in the same way as a dark skin, promotes perspirati
but at the same time acts as an obstacle to the fr
evaporation of sweat from the skin. There is betwe
the skin and the clothing a space filled with stagna
air, which in fact contains more moisture than t
surrounding air, on account of insufficient venti
tion. In consequence, the dress material becomes m
and more impregnated with moisture and the mesh
of the fabric clogged with water and the degree
saturation of the air space between skin and clothi
exaggerated. Young has recorded observations
North Queensland upon the temperature between sl
and shirt—"skin-shirt temperature"—which confi
and amplify Hill's (1914) previous experiments
the same direction, which were carried out in Engla
Wet and dry bulb thermometers were used, the bu
of which were encased in wire cages to prevent c
tact. The temperatures thus observed were inva
ably several degrees higher than the outer tempe
tures. Hill's observations, made during an Engl
winter, showed figures as high as those recorded
North Queensland, but his subjects wore heavy cl
ing, suitable to winter conditions in Europe, wher
Young's subjects only wore a thin shirt. This i
clear proof that the quantity of clothing and
nature of the material is of paramount importanc
determining the condition of the air surrounding
skin. The former does not require any further
planation; the latter, however, the nature of the
terial, may be further discussed here. It should
sess two properties, firstly, that of absorbing moist
and allowing of a maximum surface for speedy e
oration—the difference between woollen, cotton
silk material is well known—and, secondly, it sh
prevent, as far as possible, penetration of heat wa

Attempts to obain this objective have been mad
several workers, who experimented on the suitab
of material of various colours for tropical use.
question has been discussed by Sambon (1907),
based suggestions upon experiments carried out
Baly upon the penetration of rays from an ele
arc through a piece of dark pigmented skin der
from an Indian. Baly photographed the spect
after passage of the rays through the skin and not
that rays of shorter wave length than 3,600 μμ. (u
violet) were entirely absorbed, proving thus that
skin pigment excludes the ultra-violet rays. F
these observations Sambon suggested that, for t

use, material coloured black, red or orange should
used, colours which eliminate the rays of short
e length. As all these colours absorb heat rays,
suggested at first a combination of white outer gar-
nts and coloured underwear, the former to reflect
t rays, the latter to exclude actinic rays. Later
suggested the manufacture of a special material,
bining both advantages, and this has been put on
market as "Solaro." This fabric is composed of
te and suitably coloured threads, woven in such
ay as to present a warp (upper surface) of white
a weft (under surface) of orange, red or black,
it has been proved by spectroscopical examination
e as impervious to actinic rays as the black skin.
chmidt (1909) suggested the wearing of loose gar-
nts made of either thick light-coloured or thin dark-
ured material and recommended the use of ma-
al similar to that suggested by Sambon.

he practical test of coloured underwear, however,
not proved it to be advantageous. Phalen (1910)
ducted experiments on a large scale on soldiers in
Philippines. He supplied five hundred soldiers
orange-red underwear and compared their well-
g in the course of a year with another group wear-
white underwear. He compared body weight, the
ber of red cells and hæmoglobin, blood pressure,
e and respiration rate, body temperature and in-
nce of sickness in both groups. He found that
men wearing orange-red underwear showed
ges due to heat, such as loss in body weight and
oglobin and decreased blood pressure, more
ked than the control group. Phalen concluded
n his experiments that the coloured garments were
e receptive to heat rays than were the white, since
rers complained persistently of greater heat,
ter weight and increased perspiration and ex-
sed the opinion that khaki clothing alone affords
same protection from chemical rays as the special
erwear.

he question of clothing in the tropics has been
t with from a more common sense point of view
Gibbs (1917). "Clothing which in the sun will
a shade upon the body without hindering the air
lation and heat radiation will be the most desir-
and if a colour is used which will give a minimum
eat absorption, the efficiency is increased. This
l condition is fulfilled by the umbrella and it is
ent that a large white umbrella lined with a ma-
l of a colour agreeable to the eyes, for example, a
e of green, will be most efficient." He states
since custom prescribes that the man shall cover
ody, this mode of "clothing" is in fact imprac-
le and he substitutes for the umbrella a large
med helmet, casting a shadow over the back,
lders and chest, and a loosely fitting white suit
aterial as thin as possible.

dging by our own experience, the wearing of
-coloured suits of porous material assures the
mum amount of comfort possible, but it is obvi-
impossible for a labourer to wear white clothing
s work. In North Queensland he wears, as a rule,
i-coloured trousers and a thick, dark-coloured
el shirt, which prevents the sun's rays from
trating to the skin and absorbs perspiration and
allows a maximum degree of evaporation of
weat.

On the whole, an extended inquiry amongst the residents in tropical Queensland has revealed such a diversity of opinions as to what type of clothing is the most comfortable that it appears presumptuous to lay down definite rules. Many prefer cotton for underwear, others pin their faith on wool, but all agree on the one point that outer as well as under garments should be as porous and as light in weight as possible.

(4) Summary of Physiological Changes of the White Man in the Tropics.

A review of the known facts concerning the physiological changes of the white man, transplanted to the tropics, is from a scientific point of view disappointing. Throughout the literature published since the beginning of the last century many scrappy attempts have been made to obtain evidence in this respect; figures have been collected and experiments on metabolism and other physiological functions have been performed. In spite of the energy expended, the results are not conclusive; firstly, on account of the smallness of the number of observations recorded by the different individual observers, too small to eliminate individual variation and error; secondly, on account of the uncertainty of the generally-accepted standards which may be considered normal for a temperate climate. The question of body temperature is a case in point. Several observers formed their conclusions by accepting 37° C. (98.6° F.) as a normal body temperature and considering even a small rise above this as an indication of an increase in body temperature in the tropics. If a series of observations had been taken on a few subjects at intervals during the day and night, and the averages calculated, discordant results would have been the outcome, even in Europe.

The same criticism applies to experiments regarding other physiological functions, as, for example, the total metabolism as measured by the gaseous exchange. As already pointed out, a great deal of work has been attempted in Europe and recently on a much larger scale than hitherto in the large nutrition laboratories in the United States. In spite of these concentrated and intensive efforts, as Benedict has pointed out, no definite unit for the comparison of the metabolism of normal individuals has been discovered and there does not exist at present a definite knowledge of the factors influencing individual variations.

Such changes as have been noted, have been of a quantitive, but not of a qualitative, nature. Thus, with regard to maintenance of body temperature under tropical conditions, no evidence could be found in support of the view that heat, generated by internal combustion, is reduced in order to regulate the body temperature; even under the altered conditions the body still relies on physical means for this purpose. As convection and radiation of the body are greatly decreased with the high temperature, cooling must be brought about to a much larger extent by sweating and evaporation than in a temperate climate.

Again, the increased loss of fluid from the body by the skin is accompanied by a decrease in the quantity of the urine voided. As the sweat contains sodium chloride, an increased amount of this salt must be lost through the skin, which in its turn again leads to a decreased amount of salt excreted in the urine.

Blood examinations performed on a large scale have not proved the occurrence of a tropical anæmia as such, since the figures for hæmoglobin and for the formed elements do not show a definite decrease. There is a certain alteration in the percentage of the various types of white blood corpuscles and in the number of cell fragments in the polymorphonuclear neutrophile leucocytes, showing that the percentage of ‘‘young leucocytes’’ in the circulation, that is, leucocytes containing a smaller number of nuclei or nuclear fragments, is larger than in a temperate climate. This is expressed in hæmatological language as a ‘‘shift of the Arneth index to the left.’’ The significance of this change is, however, not clear, but at any rate does not seem to indicate a decreased power for resisting disease, as supposed by the Philippine observers.

The consensus of opinion gleaned from experiences in various parts of the tropics seems to indicate that living in the tropics affects the nervous system and that neurasthenia seems to be more prevalent than in a temperate climate. It is, however, impossible to obtain definite figures and data, and most statements are only based on personal experience. In the light of this it would be interesting to ascertain whether a detailed examination of the functions of the nervous system would reveal any definite alterations, which, on account of their frequent incidence, would have to be considered an outcome of life in a tropical climate.

It appears, therefore, possible that a closer study of the functions of central and peripheral nervous system might reveal definite alterations. It would be advisable to obtain figures for the promptitude and quality of the response given by the nervous system to various stimuli. Reaction times and responses to different stimuli are quantities readily capable of exact measurements by means of generally used apparatus.

An extensive investigation into the mental activities in general would perhaps yield figures of definite value. The testing of a great number of individuals in the tropics on similar lines to those applied in choosing aviators would be very interesting. The applying of the Binet-Simon test for mentality to a great number of school children, again, would furnish figures of definite value for deciding the presence or absence of racial degeneration. In the mentality tests the methods are rough and only a very large number of tests, sufficiently large to eliminate personal error on the part of the observer and to minimize the influence of a few feeble-minded children, would yield figures of value. In short, all the efforts to detect physiological changes due to living in a tropical climate have not yielded definite results. It would, however, be premature to conclude that such changes do not exist and it is possible that the advent of refined methods and more sensitive apparatus may in the future demonstrate definite alterations.

White Settlement in Tropical Australia.

(1) General Conditions and Statistics.

When comparing tropical Australia with other countries situated in the torrid zone, it becomes apparent that northern Australia occupies a somewhat unique position from more than one point of view. On the whole, the general conditions of a tropical country are modified to a much greater extent by clim *per se,* meaning seasonal incidence and degree of ra fall, than a country within the temperate zone. W the exception of a wet belt on the Queensland co mentioned previously, the rainfall is limited to a months in the year and during the remainder of year at the most an occasional light shower distu the monotony of sunshine and during about se months of the year the weather conditions corresp to the ‘‘dry tropics.’’ Vegetation, which is luxuri during the wet season, dies down and the green of countryside gives place to a uniform brown. shrivelled up undergrowth is often consumed by b fires, which are said sometimes to be started by accidental focussing of the sun's rays and which sw for miles over the country, leaving only the t standing, bare of their bark.

Many phases of insect life, which are depend on vegetation and moisture, die down during the months, only to become all-pervading again as s as the rains start. These changes are more mar inland than on the coast, since many of the inl districts have a very small rainfall and the hot wi arising from the barren desert of central Austr cause the inland plains of northern Australia to proximate to a typical ‘‘‘desert type’’ of clim with cold nights and scorching hot days.

The great bugbear of northern Australia is common occurrence of droughts, lasting for mo and even years, when the whole country is bake a pitiless, blazing sun and becomes denuded of vegetation, the ground for hundreds of miles sho hardly a blade of grass.

Another respect in which northern Australia di from other tropical regions is the sparcity of aboriginal population. The natural condition northern Australia seem to militate against a l aboriginal population and the natives have n evolved beyond the nomad state and have for an known reason never made any attempt towards s ment. The uncertain food conditions, aggravate droughts, have helped to keep down numbers. After the arrival of Europeans, th ability of the aboriginals to change their nom habits has led to a decrease in their number and prevented them from living alongside the white In consequence, in any part where a large white p lation exists, the black man has become extinct.

The white population is still very scanty a mostly concentrated in a few towns which are distances apart.

The climatic conditions, especially the small erratic seasonal rainfall, in conjunction with scarcity of population, have created the unique tion which northern Australia holds to-day. long dry season influences the insect life and tropical diseases which are tranmitted by certai sects, such as the mosquito, are apt to show a sponding seasonal incidence and are to a certai tent kept in check. Other diseases, such as infe and contagious ailments, are in a similar way down by the sterilizing action of the sunlight, may kill the virus before it can spread over larg scantily populated areas.

The contention that the prevalence of certai eases is favoured by larger and more evenly uted rainfall is borne out by the fact that in dis- ts situated within the wet belt a greater incidence ertain diseases is observed. Various fevers, such ndemic glandular fever, other scrub fevers of un- wn ætiology, which are most probably insect- ne, occur throughout the wet belt, but are absent n other drier districts. In the same way hook- m disease is far more prevalent in those places re the rainfall is higher and is, as far as our pre- experience goes, practically absent from other ricts showing similar local conditions but a smaller strictly seasonal rainfall.

he effects of climate and surroundings upon any finds a clear expression in the vital statistics, as birth and death rates, infantile mortality rates expectation of life.

he statistical data for North Queensland and hern Australia have not been published separately comparison with similar statistics for the rest of tralia; moreover, it is impossible to obtain defi- data as to the number of inhabitants in Australia, e the last census took place in 1911, and the popu- n of northern Australia is of a migratory char- r; any figures obtained are therefore only of ap- imate value. The Commonwealth Statistician, G. H. Knibbs, C.M.G., was able to supply informa- which throws light upon this question and has ly given permission to include his statements in present publication.

e area and population of the tropical portion of Commonwealth are shown in the following table:—

AND POPULATION OF THE TROPICAL PORTION OF AUSTRALIA.

al Portion of—	Area in Square Miles.		Population (Exclusive of Full-blooded Aboriginals) at Census of— 1881.	1891.	1901.	1911.
ern Territory	426,320	..	3,451	4,898	4,096	3,310
sland	359,000	..	56,041	108,986	145,982	157,112
ern Australia	364,000	..	661	3,711	4,664	4,998
otal	1,149,320	..	60,153	117,595	154,742	165,420

ese figures relate to all that portion of the Com- wealth which lies to the north of the Tropic of icorn. For the tropical portions of Queensland Western Australia population figures are avail- at the date of a census only. For the Northern itory they are compiled quarterly and the returns December 31, 1917, give a total of 4,908—an in- e of 1,598 since the census of 1911.

the census of 1911 the total population of nsland (exclusive of full-blooded aboriginals) 605,813, so that at that date the tropical popu- n of Queensland represented rather more than of the total. It also represented about 95% of the total tropical population of Australia. It might consequently be presumed that any unhealthiness of tropical Australia would have left its impress on the vital statistics of Queensland. That this is not the case is clearly shown from the following comparison of the Queensland death rates per 1,000 of population with those for the Commonwealth as a whole:—

COMPARISON OF QUEENSLAND AND COMMONWEALTH DEATH RATES, 1906 TO 1917.

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
Queensland..	9.50	10.31	10.26	9.70	9.71	10.65	10.96	10.39	9.97	11.00	11.09	9.64
Commonwealth	10.92	10.99	11.07	10.33	10.43	10.66	11.23	10.78	10.50	10.66	11.04	9.80

It will be seen that in ten out of the twelve years under review Queensland recorded a lighter death rate than the Commonwealth as a whole and that in one of the other two years (*viz.*, 1916) the difference was inappreciable. The remaining year (1915) was that in which Queensland suffered from the most severe drought even known there, while the greater part of the remaining States experienced normal conditions, have suffered from drought in the preceding year.

Another test of salubrity often applied is that derived from a comparison of the deaths of infants under one year of age with the total births. The rate so deduced (*i.e.* the number of deaths of infants under one year of age per 1,000 births) is what is generally known as the "infantile mortality." A comparison of the Queensland results with those of the Commonwealth as a whole for the past twelve years is furnished in the following table:—

COMPARISON OF QUEENSLAND AND COMMONWEALTH INFANTILE MORTALITY, 1906 TO 1917.

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.
ueensland	74.68	77.65	70.67	71.50	62.90	65.36	71.73	63.35	63.93	64.33	70.27	53.87
ommonwealth	83.26	81.06	77.78	71.56	74.81	68.49	71.74	72.21.	71.47	67.52	70.33	55.91

In every one of the twelve years under review the infantile mortality of Queensland was more favourable than that of the Commonwealth as a whole. Further, in both the foregoing tables the comparison has been between Queensland on the one hand and the Commonwealth, inclusive of Queensland, on the other. A comparison between Queensland and the Commonwealth exclusive of Queensland would have given results even more favourable to Queensland than those deduced above.

In the absence of complete data in respect to the population and mortality of the tropical parts of Australia it is impracticable to carry the test further, but the figures given above indicate that the vital statistics of the Commonwealth furnish no evidence of lack of salubrity in those parts. On the contrary, the State having 25% of its population within the tropics and containing some 95% of the tropical population of the Commonwealth, has a record for general and infant mortality much more favourable than that for the Commonwealth as a whole. It may be noted that practically the whole of the State of Queensland lies in the north of the twenty-ninth parallel of south latitude.

Striking as the foregoing Queensland figures are in comparison with those for the whole of Australia, an even more telling result is obtained by comparing them with those of some of the leading European and other countries.

Country.	Year.	Death Rate.	Rate of Infantile Mortality.
Queensland	1913	10.4	63
Commonwealth	1913	10.8	72
Netherlands	1913	12.3	91
Denmark	1913	12.5	94
Ontario (Canada)	1913	12.7	117
Norway	1913	13.2	65
Sweden	1913	13.6	70
England and Wales	1913	13.8	108
U.S.A. (registration area)	1913	14.1	*
Switzerland	1913	14.3	96
Belgium	1913	14.8	120
Germany	1913	15.0	151
Scotland	1913	15.5	110
Ireland	1913	17.1	97
France	1913	17.7	98
Italy	1913	18.7	137
Japan	1913	19.5	150
Austria	1913	20.5	180
Jamaica	1913	21.7	171
Spain	1913	22.1	*
Hungary	1913	23.3	186
Rumania	1913	25.9	202
Ceylon	1913	28.4	189
Chile	1913	30.1	255

* Not available.

In addition to the foregoing, it may be pointed out that the mortality experience of Queensland has been continuously improving, both absolutely and also in relation to the experience of the Commonwealth as a whole. This is clearly brought out in the next table, showing the expectation of life at age 0 in each of the last three decades.

EXPECTATION OF LIFE AT AGE 0.

Decade.	Males.		Females.	
	Queensland. Years.	C'wealth. Years.	Queensland. Years.	C'wealth. Years.
1881-1890	41.330	47.199	49.754	50.844
1891-1900	49.512	51.076	55.800	54.756
1901-1910	54.203	55.200	59.294	58.837

In Mr. Knibbs's opinion local statistics relating to individual towns would not give results sufficiently reliable to warrant definite conclusions, owing to the migratory character of much of the population, and, in connexion with birth, owing to the tendency to move into the towns for purposes of confinement.

(2) Housing.

The question of the construction of suitable dwellings in the tropics has been the object of a great deal of study and controversy. A suitable tropical residence should be so constructed that the interior is protected as much as possible from the direct rays of the sun, in order to prevent excessive heating of the walls of the room and at the same time sufficient ventilation should be provided, in order to secure the quickest possible cooling of the structure. Unfortunately, in the construction of the average dwelling house in North Queensland these principles have not been sufficiently considered. The greater proportion of the dwellings of the settlers on the land are entirely unsuitable and a great number in the larger towns are far from ideal. A statement of a leading firm of architects with twenty years' experience in the north is of interest, namely, that they have never designed one cottage as they know a cottage should be designed, on account of the prejudice against the introduction of novel ideas.

The majority of the scattered habitations of the smaller settlers in north-western Queensland are built of galvanized iron on a wooden framework, without
verandahs or any insulation, and the temperature
the interior during the hot hours of the day surpas
by far the outer air temperature.

The small dwellings in the towns are raised on pi
and contain as a rule four rooms; they possess a n
row verandah in front and sometimes also on the si
The rooms are as a rule low and the roof is compos
of galvanized iron sheets and often does not poss
an inner lining. The kitchen is nearly always
tached and generally consists of a small cubicle bu
of galvanized iron only. Most of the larger woo
houses have a verandah all round and higher roo
with ample ventilation.

A good type of tropical house may be seen in D
win, where many of the houses are constructed af
a design similar to houses in the Far East. T
verandahs are wide and are closed in by bamb
shutters, which are kept shut during the heat of
day and thus prevent the heating up of the rooms
at the same time allow of sufficient ventilation;
shutters are opened as soon as the sun gets low.

It is quite evident that a galvanized iron "hump
without verandah, is the most unsuitable structure
reside in in a hot climate. During the day the h
is nearly unbearable and the only advantage is
speedy cooling of the walls after sundown. The lar
houses, built of timber, with open verandahs, are,
the whole, suitable for the climatic conditions, if
tention has been paid to several points.

The house should be raised off the ground and b
on piles, in order that the air should have free ac
to every part of the house. It should be so pla
if practicable, that it lies in the direction of the
vailing breeze and windows and doors should as
as possible be opposite, in order to allow of the m
mum of ventilation. The verandah should be
ficiently broad to protect the walls from the di
rays of the sun at any time, but the minimum w
depends upon the latitude in the geographical se
According to Schilling (1909), the houses in reg
near to the equator require a verandah on the
sides, as the path of the sun is more vertical.
regions below the Tropic of Capricorn a veran
on the south side is not absolutely necessary, as
path of the sun is inclined from the north and
south side of the house is not struck by the di
rays at any time. The rooms should be spacious
with as many windows and doors as practical, for
sake of ventilation and lighting. It is only too
known that mosquitoes and other insects choose
corners and avoid light. A roof of galvanized ir
suitable, provided that the necessary ventilatio
allowed for. The roof should be slightly raised
the wall. The top gable should be provided wi
ventilator and, if possible, there should be louvre
either side below the gable, to provide additi
ventilation. If the roof be closed in, there is a
of hot, stagnant air between the roof and the ce
of the rooms, which is heated by the sun to a hi
temperature than the outside air and this keeps
temperature of the rooms high for some time
sunset.

We are indebted to Messrs. Lynch and Hunt, a
tects, of Townsville, whose activities extend thro
out North Queensland, for the framing of the fo
ing recommendations for building small dwellings

e for North Queensland and costing approximately m £200 to £600.

Apart from any further items that may be found advisable, as many of the following recommendations as the site will permit should be embodied in every cottage:—

1. Buildings should face due east and have verandahs to front and back of not less than nine feet in width.

2. In addition to other necessary openings, there should also be doors and windows so arranged in every room to allow the wind to enter on the weather side and escape on the lee side. Doors should also be arranged as to avoid the necessity of retracing one's steps to get to any section of the house.

3. Buildings should not be more than one room in depth.

4. The size of a room built under the most favourable circumstances should be regulated by the number of prospective occupants. Eight hundred cubic feet per head would be a fair minimum

5. Side verandahs and excess widths to other verandahs should not be constructed at the expense of the size of the ooms. Large ooms and limited erandah space ire infinitely beter than small ooms and wide erandahs.

6. Blocks should e approximately feet 6 inches above the ground. They should be ither brick or oncrete.

7. All buildings hould be contructed to resist yclones.

8. Fully exposed valls should be ouble sheeted nd ventilated.

9. Roofs should e fitted with entilators.

10. Ceilings hould stand two eet below the op of top plates. n this connexion tudding should ot be less than welve feet in ngth for the mallest cottage nd proportiontely longer for rger cottages.

11. Fan-lights should be hung immediately under eilings.

12. Ledges and corners should be avoided as far as ossible.

13. Roofs should be hipped and continuous, having ives approximately two feet in width, to walls and randahs.

. C. D. Lynch has kindly put at our disposal a suggestion for building suitable houses, which l entail an expenditure of at least a thousand ds and which scheme is the outcome of twenty ' practical experience of house designing in North Queensland. The building, the idea of which is shown in the accompanying sketch (Fig. VI.), is constructed of re-inforced concrete or brick and possesses double outer walls, with an intervening and suitably ventilated air space of about three inches, thus ensuring coolness and dispensing with the necessity of verandahs. The floor space is subdivided by wide corridors (3.5 to 4.5 metres, or about 12 to 15 feet) arranged in the form of a cross, on to which the rooms, placed at the corners of the house, open. The corridor may serve as a general living room, since it enjoys the maximum amount of ventilation, whatever the direction of the wind may be. A flat roof, surrounded by a balustrade, would, according to Mr. Lynch, add further to the roominess and comfort of the building.

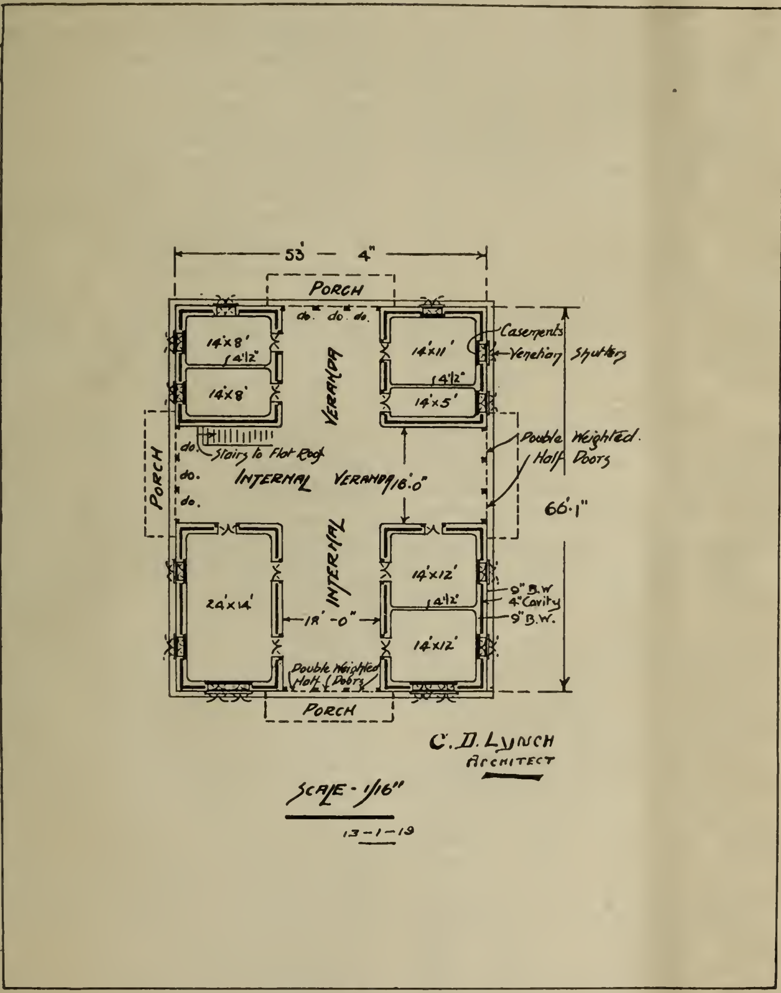

FIGURE VI.
(Reduced one half from original drawing.)

Suggestions are found in the literature for cooling houses by artificial means. Attempts have been made to circulate artificially cooled air through buildings, but in practice this method has not proved satisfactory, on account of the high initial expense of the necessary machinery and the technical skill required for its maintenance. Less costly, but at the same time less effective means are fans run by electrical or water power; but as the majority of the northern towns of Queensland are without electrical power and as the water rate is excessive and the supply often uncertain, fans in private houses have not come into general use.

The systematic laying out of towns in tropical Australia has unfortunately been sorely neglected and most settlements have been allowed to grow up in a haphazard way. In the main streets of the larger towns ground has become too valuable to permit of an adequate space between buildings to allow free circulation of air. The main streets have often been laid out regardless of the prevailing winds. Flinders Street, the main street in Townsville, runs in the direction from north to south, the prevailing breezes blowing from south-east, and, as a result, the street has the well-deserved reputation of being the hottest corner in North Queensland. If, in the original laying out of the town, this point had been considered and a number of cross streets in the direction of the prevailing winds allowed for, a great deal of discomfort might have been spared.

General Résumé.

A consideration of the position in northern Australia at present shows evidence that the progress in North Queensland and to a still greater extent in the Northern Territory, has not been commensurate with the advance of time and with the undeveloped resources of the country. Certain townships, without doubt, have gone ahead, have increased in population and prosperity, but at the same time other towns have ceased to prosper, have decreased in population and their inhabitants have migrated to the prospering townships. It is, however, difficult to get definite figures which would illustrate this point, as the census is only taken every ten years, but the relatively small increase of the population of the north when compared with the south of Queensland during the decade between two census (1901-1911) is significant. The total increase in population for Queensland during this time amounted to 108,657 souls; of these, only 7,577 represent the increase in the north. Considering that in 1911 25% of the total population of Queensland was living in the northern division, the increase in this district was relatively much smaller than in the centre or in the south. Even if figures for the last seven years could be obtained, their value for gauging the progress of the country would be doubtful, on account of conditions brought about by the war, which led to a nearly complete cessation of immigration.

The population of the Northern Territory has slightly increased lately. Even so, at the end of 1917 the total population was 4,908, representing approximately one inhabitant to about 80 square miles.

It is therefore obvious that northern Australia is not as favoured for settlement as the southern parts of the Commonwealth and in this connexion it was pointed out by Sir Thomas Anderson Stuart on the occasion of a meeting of the Royal Colonial Institute in 1912 that the southern and more salubrious parts of Australia were not by any means overpopulated yet and that immigrants naturally preferred to settle there than to go further afield; thus, in the course of time, they would find it an easier matter to obtain a setlement in the northern parts than in the south. It was simply a case of filling up and the rapidity would depend on the rate of immigration. A similar conclusion was arrived at by Atlee Hunt (1915) regarding the Northern Territory. "Should any new and rich mining field be discovered, the question of populating the Territory will settle itself; but in the absence of any such happening, it is submitted that the only course open is to wait until, in the natural course of things, the trend of population moves gradually northward."

It is well known that economic conditions play an important part in the settlement of any country, and especially of the tropics. There is no doubt that in the tropics is burdened with a great deal of comfort, due to heat and other general conditi brought about by climate. For this reason the set ment of the tropics carries with it more difficul than settlement in a temperate climate. This is bo out in practice by the experience that, throughout world, the white population in tropical parts is larg of a migratory character. Tropical Australia does form any exception to this rule. Even during a c paratively short residence one notices that the po lation is continuously changing and that there ex a general desire amongst the inhabitants that th stay in the north shall be as short as possible, and whole aspect of the majority of northern towns testimony to this. A lack of public interest is noti everywhere and has led to putting up with ma shifts. Houses are only rarely built for comfort their owners hope to occupy them only for a few ye Town improvements are often only of an ephem character and short-sighted policies are the rule most instances. This again is due to the unset mental condition of a migratory population, whic unable to concentrate on anything but the most pr ing immediate needs.

Many conditions co-operate in bringing about state of affairs. North Queensland is the most cently settled part of Australia; it is an enorm stretch of country, with comparatively few lines communication with the centres, and consequentl has received a great lack of consideration from centres of government. A feeling of isolation natural outcome and exaggerates migratory tender and the desire to get back to "civilization."

The hot summer naturally militates against manent settlement, especially since the housing, of water, etc., do not mitigate the severe discomf If a person residing in northern Europe were obl to live during a severe winter in a draughty woo house, without artificial means of heating, a st desire to move to a more congenial climate woul created. In the same way one could not expect a w population to thrive in the tropics unless all pos means be adopted to alleviate climatic conditions.

Many newcomers arrive in the North with a judice against northern Australian heat, which been instilled into them by their southern friends adds greatly to their discomfort. Dressed in southern clothing they walk about perspiring, never think that a cold day in the south, spent light cotton suit, would be equally, if not more, comfortable for the opposite reason.

In addition to climatic influences, the mode of ployment in general tends to attract a migratory p lation. North Queensland is dependent almost tirely on raw products for supporting its inhabi and permanent institutions, such as factories, gi employment throughout the year, are lacking.

The settler in the north has thus to face condi which, when compared with those of a tempera climate, render life in one way more uncomfort although in another way less strenuous on accou the lack of competition. During the hot season is carried out under trying conditions; the leas ertion causes profuse perspiration, the degree of fort depending mostly on the nature of the work on the surroundings, but is well pronounced, even eople who follow a sedentary occupation. In addi-, during the very hot months of the year, the con-ous pouring out of perspiration during the day ot relieved by a respite during the hot night, when, ough at rest with doors and windows wide open, perspires freely and wakens up in the morning efreshed and more tired than one felt on going ed.

requires but little thought to realize that this omfort plays a still more important part in the of the women. Their work—domestic duties—is ied out during the hottest part of the day, indoors ie hottest part of the house and in most instances hat part which has been most neglected in con-ction. It is very difficult to obtain domestic help, ccount of the small number of domestic servants lable, whose wages are in consequence very high, anding an expenditure which is in most instances ibitive for a medium income. The wife of the er on the land is in a still worse plight, as she has only to do her own housework, but in many in-es has to cook for the employees. There is, in no eight-hour working day for these women.

man is largely affected by his surroundings and quality and quantity of his work influenced by conditions, it can be readily understood that a ical climate with a hot atmosphere laden with ture, where the discomfort following any bodily ion is great, is not conducive to a maximum out-of energy, especially if the lack of competition s the condition of life easy. There is no doubt climate *per se* tends to affect greatly the quality quantity of physical and mental work. A cold it[illegible]nduces to physical activity, a warm climate ssitude and the economic conditions are then the mining factor for the output of energy.

North Queensland, with its enormous natural re-es, its remarkable recuperating power after a of bad seasons and its small population, the tions of life are such that poverty is unknown n easy living can be earned at a minimum cost of ion and the rate of wages is very high.

other factor which plays a very important part e determination of the quality of work is the of alcohol, which is rampant amongst all classes community. A number of factors contribute to buse, such as the thirst caused by the heat, the ation to quench this thirst, owing to the great er of licensed public houses, the temporary lating effect of the slow poison and last, but not the well known open-hearted hospitality of the which finds its expression in "shouting."

foregoing observations prove that in North nsland both climate and economic conditions, y, the lack of competition and high wages, have d a tendency in the same direction, towards a oration of labour, and it is impossible at present portion correctly the influence of either factor. quite probable that, in the future, when the ation of northern Australia has increased and tition has become keener, the quality of labour mprove, unless in the meanwhile a definite de-the race, due to climate, has set in. Up to the nt, however, no such decay is apparent, but it must be kept in mind that in a newly-settled country, with a floating population, which, to a great extent, is maintained by immigration, racial degeneration would not make itself felt until after a somewhat prolonged period.

The "Great Experiment of White Australia" in most previous discussions has been considered entirely from one point of view, namely, the health point. It has been assumed that the possibility of a population of European descent to live, propagate and thrive in a tropical climate, alone would decide the question. In northern Australia, however, the economic conditions are of equal importance and present a problem as far-reaching in its influence as health for the permanent settlement of tropical Australia.

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om the *Proceedings of the Linnean Society of New South Wales, 1919, Vol. xliv., Part 2, 27th August.*]

USTRALIAN *STRATIOMYIDÆ (DIPTERA)*, WITH DESCRIPTION OF NEW SPECIES.

By Gerald F. Hill, F.E.S., Entomologist, Australian Institute of Tropical Medicine, Townsville, N.Q.

In his revision of the Australian *Stratiomyidæ*, White* lis 30 species belonging to 18 genera. In the following paper t writer proposes six new species, belonging to five genera, of whi two genera have not been recognised hitherto in Australia. T apparently rare fly *Negritomyia albitarsis* Bigot, previously know from Papua and Queensland, is recorded from the Northern Te ritory.

The specimens are all in a perfect state of preservation. Th examination for the purpose of description was made in daylig with No. 4 ocular and 2 inch objective. Measurements are giv in millimeters. The figures were outlined with camera lucida.

Family STRATIOMYIDÆ.

Subfamily BERINÆ.

ACTINA VICTORIÆ, n.sp. (Figs. 1*a*, 1*b*, 1*c*).

♂. Total length, 6·0; wing, 4·7.

Frons, vertex and thorax dark bronze-green; antennæ bla abdomen dark brown, with brownish yellow areas on segme three, four and five.

Head wide (1·55), wider than prescutum (1·30); eyes separa by a space (the frons) of ·15, widening to ·30 at the vert vertex, upper part of frons, and clypeus clothed with long bl hairs; lower part of frons and sides of face covered with silv tomentum, genæ clothed with long white hairs; antennæ inse slightly above the middle of the head in profile, ·90 long, first

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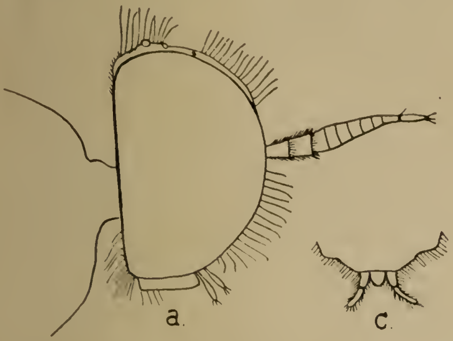
* These Proceedings, Vol. xli., 1916, Pt. 1, p. 71.

cond joints about equal (·15), both covered with stiff black hairs,
ird joint longest (·45) with seven indistinct segments and a ter-
inal style (·15 in length) bearing three or four long hairs at the
pex; palpi black; mouth parts stramineous; eyes only moderately
airy, clypeus and lower part of frons not projecting, and the
ellar plate projecting only very slightly in front of the eyes
Fig. 1*a*).



Text-fig. 1.
Actina victoriæ, n.sp.; *a*, male; *c*, female.

Thorax densely covered with long black and short pale hairs;
tellar spines long, bases dark like scutellum, the remainder pale
llow; halteres pale stramineous.

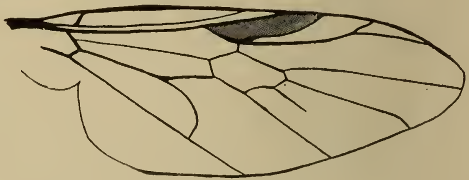
Legs: fore- and mid-legs dark ochraceous, with second-fifth tar-
ls brown; hind legs similar, but with distal half of femora and
iæ dark brown or suffused with brown.

Wings light smoky, veins and pterostigma brown, third pos-
ior vein extending one-third of the distance to the wing border
ig. 1*b*).

Abdomen long and narrow (3·75 long by 1·35 wide), the sides
thed with long pale hairs; the greater part of the dorsum of the
ird, fourth, and fifth segments occupied by a brownish-yellow
a, roughly triangular in shape, the apex directed posteriorly.

♀. Total length, 5·0; wing, 4·40.

Frons, vertex and thorax dark bronze-green; antennæ rusty re shading into black beyond the second joint; abdomen bright orang brown with brownish-black segmentations, the first and sevent segments entirely brownish-black; genitalia prominent, brigh orange brown (Fig. 1*c*).



Text-fig. 1*b*.
Actina victoriæ, n.sp., male.

Head (1·30 wide), narrower than in male, wider than prescutu (1·15); eyes (·30 apart) parallel on their inner margins, no lon black hairs on vertex and frons and very few on clypeus; gen as in male, mouth parts yellowish; palpi dark ochraceous; ey almost hairless; antennæ about ·85 long, first and second join rusty red and clothed with short stout black hairs, third joi entirely black, or shading from rusty into black towards its ape style black.

Thorax without long black hairs. Legs dark ochraceous, seco and fifth tarsals of each leg and the apices of the femora a tibia of the hind legs shaded brown.

Hab.—Vic.: Ararat, April 1917.

Described from two females and nine males taken on the wi from a small flight at Native Cherry Tree (*Exocarpus*).

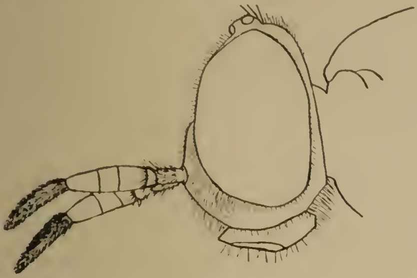
Subfamily CLITELLARINÆ.

NEGRITOMYIA ALBITARSIS Bigot. (Fig. 2).

♀. Total length, 10-11; wing, 9·5.

Clypeus, head, thorax and abdomen black, covered with silv pubescence; dorsum of thorax, scutellum and scutellar spines w black hairs

Head: eyes nearly parallel along the inner margins, den lothed with short silvery pubescence; ocellar triangle prominent, hairy; frons wide (·70), sides clothed with silvery pubescence; clypeus densely pubescent; mouth parts dark brown. Antennæ lark buff, the first and second joints clothed with stout black hairs, third joint bare, with three fairly distinct segments, the first longest, the second longer than the third; style black, densely clothed with black hairs (Fig. 2).



Text-fig.2.
Negritomyia albitarsis, Bigot, female.

Thorax narrower than abdomen, prescutum slightly wider than ead, scutum (3·5) wider than prescutum; side spines stout, black, shining; scutellar spines long, black at base, yellowish brown at ip.

Wings dark smoky with clearer areas towards middle and base.

Legs: femora and tibiæ black, knees and first tarsi light yellowsh brown, remaining tarsi darker.

Abdomen (6 long and 4 wide) black with silvery pubescence, hiefly on sides and median line of segments 3, 4 and 5. Genitalia ather prominent, yellowish.

Hab.—Northern Territory: Darwin, October, 1916.

Three females taken on foliage of garden plants.

(*Note.*—Bigot's specimen (female) is from Papua*. The male s unknown to me. White† describes a male from Mackay, Queensland, in Froggatt's collection.)

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* Ann. Ent. Soc. Fr., 1879, p.207.

† These Proceedings, Vol. xli., 1916, Pt.1, p.83.

HERMETIA PALLIDIPES, n.sp. (Figs. 3*a*, 3*b*).

♂. Total length, 13; wings, 11·5.

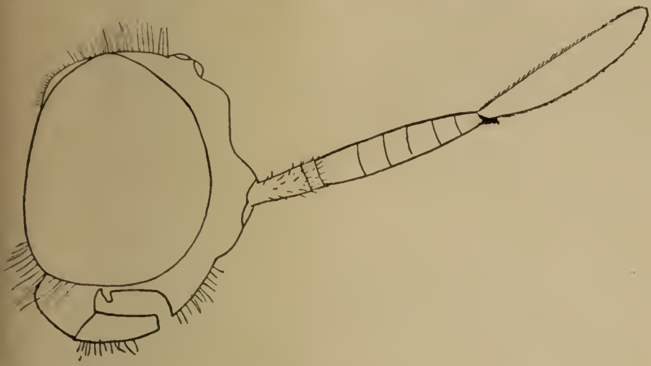
Clypeus, frons, vertex, humeral calli, a small area at the posterior angles of the prescutum, another at the posterior angles of the scutum, the apex of the scutellum, the pronotum, and the episternum pale horn colour; the knob of the halteres and two large spots on the anterior margin of the second abdominal segment pale greenish fading to yellowish after death; thorax black; abdomen black with silvery reflections on second, third, and fourth segments; mouth parts creamy buff; antennæ rusty red.

Head wide (♂, 4·5, ♀, 3·80), wider than long (♂, 2·75, ♀, 2·50); eyes densely pubescent, widely separated; clypeus wide (♂, 2·05, ♀, 1·75), projecting well in front of head, clothed with moderately long white hairs; genæ clothed with long white hairs; frons wide, projecting, the sides converging slightly towards the vertex, an oval, dark area, as long as the frons is wide, occupying the middle of the frons; ocellar tubercle small (·40 wide), black, with a few dark hairs, a small area above it dark; vertex wide (♂, 2·0, ♀, 1·25) with numerous long white hairs. Antennæ 5 mm. in length, first joint (·55) nearly four times as long as second, proximal half black, the remainder rusty red like the second, both joints widest at apex and clothed with short, stout, black hairs; third joint clothed with golden pubescence, long (2·0), tapering gradually to the apex, with six indistinct segments, the first three rusty, the others shading into dark brown; style as long as third joint, dark brownish black, convex and densely clothed with short stiff black hairs on one side, concave and bare on the other (Fig. 3*a*).

Thorax finely punctate; prothorax small, narrow (1·35), inconspicuous, glabrous; prescutum (2·85) much narrower than head, clothed with white hairs (longest on sides), and a few black hairs; scutum (3·5) wider than prescutum; scutellum not spined (generic character), rounded at the apex, clothed with short hair above and longer hairs on the sides.

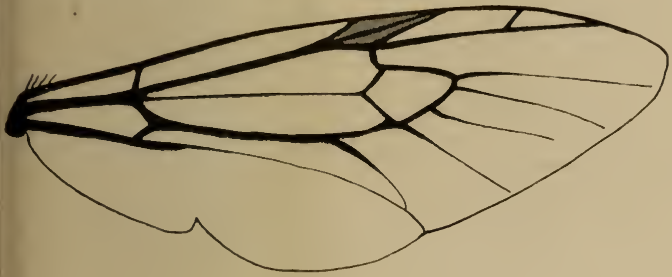
Legs: femora black, fore- and mid-tibiæ with proximal hal

reamy, remainder suffused with light brown, densely clothed with
hort white hairs; tarsi creamy buff, hind tibiæ with apical two-
ifths dark brown, otherwise like fore- and mid-tibiæ. Wings
moky brown, lighter near base, nervures darker; base of large



Text-fig.3*a*.
Hermetia pallidipes, n.sp., male.

ervures setose, surface of wing clothed with minute hairs, those
n the anal lobe longest, pterostigma small, as dark as nervures.
enation as shown in Fig. 3*b*.



Text-fig.3*b*.
Hermetia pallidipes, n.sp., male.

Abdomen at widest part, *i.e.,* the second segment, as wide as
utum, tapered gradually to the truncate apex; first segment with
ort dusky and long white hairs; second, third and fourth seg-
ents broadly margined posteriorly with silvery pubescence, the

remainder of each segment clothed with short black pubescence, fifth segment black.

♀. Similar to ♂. Antennæ about 4 mm. long, first and second joints dark buff, the former (·40) twice as long as the latter; vertex less hairy than in male, abdomen relatively shorter and broader; silvery pubescence on abdomen less conspicuous.

Hab.—Northern Territory: Darwin, 13th Feb., 1915.

Described from one male and one female, taken on foliage of garden plants.

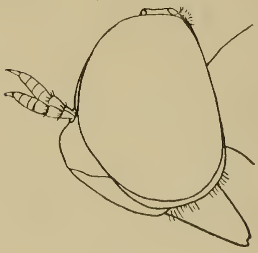
(*Note.*—This genus has not been recorded previously from Australia.)

Subfamily STRATIOMYINÆ.

ODONTOMYIA PALLIDA, n.sp. (Figs. 4*a*, 4*b*).

♂. Total length, 7; wing, 5·75.

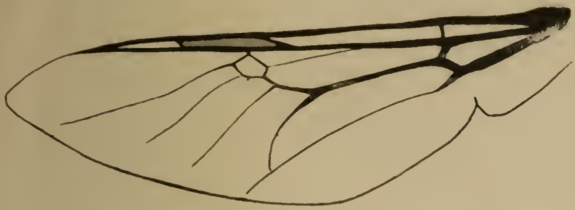
Head wider than long (2·55 by 1·90); eyes: upper half lighte coloured and more coarsely facetted than lower, widely separate below, converging immediately above the insertion of th antennæ; antennæ dark ochraceou arising about the middle of the head i profile, ·90 in length, first and secon joints equal in length, fringed with few short stiff hairs at apex, third join long with four indistinct segments an a short terminal style; clypeus ligh stramineous, prominent, triangular, bar genæ light stramineous, with a fe short hairs, parafacials prominent; pr boscis brownish black; ocellar plate black, longer than wide, wi a few short golden hairs and broad scales (Fig. 4*a*).



Text-fig. 4*a*. *Odontomyia pallida*, n.sp., male.

Thorax blackish, completely covered with short golden yell hairs and broad scales, producing a brassy appearance, apex scutellum dark ochraceous, rounded and armed with two ve small spines, humeral calli and pleura dark stramineous, stern blackish. Halteres pale greenish yellow. Legs uniform da stramineous.

Wings hyaline, veins and pterostigma pale yellowish; the posterior veins, excepting the base of the first and fourth, very indistinct, only a vestige of the third, the fourth issuing from the second basal cell (generic character), none reaching the wing border. (Fig. 4*b*.)



Text-fig.4*b*.
Odontomyia pallida, n.sp., male.

Abdomen pale stramineous, anterior half of first segment dark brown medially, this area becoming narrower and obscure posteriorly, scarcely visible in the anterior border of the second segment, but darker and wider posteriorly, widening and occupying nearly the whole of the third and the entire fourth segments.

10 ♀. Unknown.

Hab.—Northern Territory: Darwin, July, 1918. Type unique.

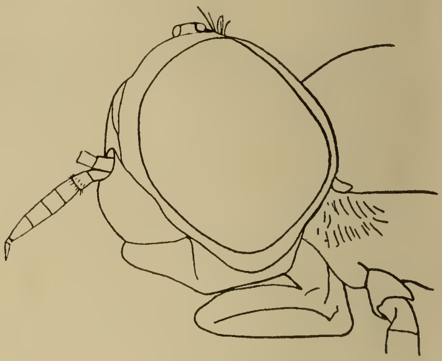
ODONTOMYIA OBSCURA, n.sp. (Figs.5*a*, 5*b*).

♀. Total length, 12; wing, 9.

Head: eyes finely facetted throughout, widely separated, converging from 2 mm. about the middle of the frons to 1·45 mm. at the vertex. Vertex, ocellar plate, and upper part of frons black, with a few short golden hairs; lower part of frons, the clypeus and genæ dark stramineous; proboscis black; frons with a deep median suture extending from the ocellar plate to the insertion of the antennæ; antennæ arising slightly above the middle of the head in profile, 1·5 in length, rusty red freckled with white, bare excepting for a few short stout hairs at apex of second joint; first and second joints equal in length (·20), third joint nearly five times as long (·95), style short (Fig. 5*a*).

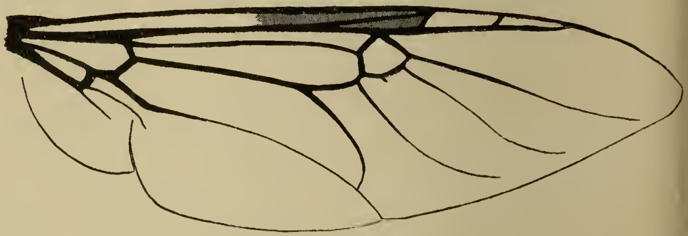
Thorax black, clothed with short golden hairs, longer towards the sides; posterior border of scutellum rounded, dark stramineous, with two moderately long spines and some long golden hairs; pleura and halteres pale stramineous; sternum blackish.

Legs dark ochraceous, tarsi of hind legs rusty.



Text-fig.5*a*.
Odontomyia obscura, n.sp., female.

Wings hyaline, costa and sub-costa dark ochraceous, other veins and the pterostigma brown; third posterior vein reduced to a short spur, none of them quite complete (Fig. 5*b*).



Text-fig.5*b*.
Odontomyia obscura, n.sp., female.

Abdomen: first segment dark brownish black with greenish yellow spot at each side; second segment with triangular brownish black mark occupying about half the segment, the remainder brownish, with obscure greenish blotches; third segment similar; fourth segment chiefly dark brownish black, sides similar to segments 2 and 3; fifth segment chiefly dark brownish black, remainder mottled with brown and greenish; on the ventral side the first segment greenish yellow, the remaining segments dark brown.

♂. Unknown.

Hab.—Northern Territory: Darwin, 4th June, 1916. Type unique.

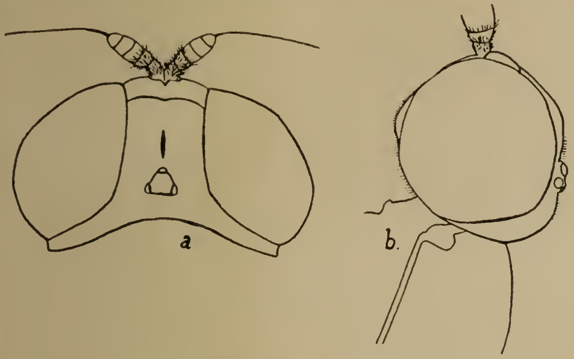
Subfamily SARGINÆ.

Sargus gselli, n.sp. (Figs. 6*a*, 6*b*, 6*c*).

♀. Total length, 7·5; wing, 6·0.

Head, thorax and abdomen metallic peacock blue to metallic cyanine blue, lower part of frons silvery, clypeus black, mouth parts yellowish.

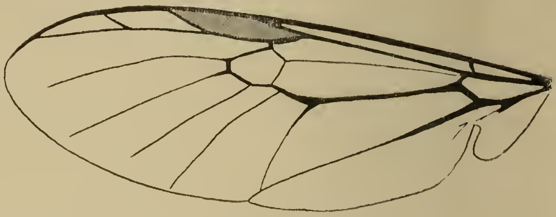
Head wide (2·40), wider than prescutum (1·60); eyes bare; antennæ pale rusty, arising from about the middle of the head in profile; first and second joints about equal in length (·10), clothed with short stout hairs; third joint three times as long as the first with two long hairs at apex; arista long (·90), terminal; frons convex, ·65 wide, increasing to ·80 at vertex, almost hairless, a cleft-like suture down median line from ocellar triangle to near the insertion of the antennæ. Ocellar triangle prominent, occupying about one-third of the width of the vertex; clypeus black, almost hairless; proboscis stramineous. (Figs. 6*a* and 6*b*).



Text-figs. 6*a*, 6*b*.
Sargus gselli, n.sp., female.

Thorax with fairly prominent humeral calli, nearly parallel along the sides, 1·75 wide; scutellum bluntly rounded behind, the whole thorax lightly clothed with short pale hairs.

Legs: fore legs with coxæ, trochanters and tarsi pale stramineous, distal half of femora and proximal half of tibiæ suffused with brown, the remainder pale stramineous, mid legs similar, with entire tibiæ blackish; hind legs, coxæ and distal half of femora blackish; tibiæ and tarsi pale stramineous suffused with brown. Wings pale smoky, veins and pterostigma dark brown; venation as shown in Fig. 6*c*.



Text-fig. 6*c*.
Sargus gselli, n.sp., female.

Abdomen about as wide as head, parallel on the sides, posterior margin of segments bordered with short white hairs. Genitalia prominent.

Hab.—Northern Territory: Bathurst Island, October, 1916. Type unique.

Named in honour of Reverend Father Gsell, whose hospitality and cordial assistance are freely extended to visitors to this locality.

The intense colouring of this species renders it a conspicuous object. Hitherto the genus has been known in Australia by only one described species, *S. meridionalis* White. There are one or two additional species in the Australian Institute of Tropical Medicine, Townsville, from North Queensland (Kuranda).

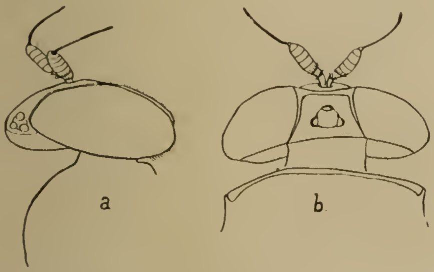
Subfamily PACHYGASTRINÆ.

WALLACEA DARWINI, n.sp. (Figs. 7*a*, 7*b*, 7*c*).

♀. Total length, 4·25; wing, 4.

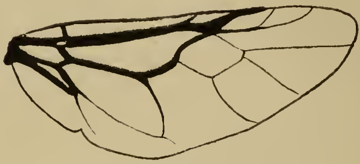
Head, thorax, abdomen, femora, tibiæ black; tarsi, wing, veins, pterostigma, antennæ ochraceous; wings hyaline.

Head wide (1·65), as wide as prescutum, eyes finely facetted, nearly parallel on inner margins, with scattered, fine, whitish hairs; clypeus glossy black, convex, depressed in the median line, with a few short, silvery and black hairs, bordered laterally by a narrow fringe of silvery pubescence; genæ greatly reduced, clothed with blackish hairs; antennæ inserted above the middle of the head in profile, pale rusty, covered with short hairs, first joint short (·048), as wide as long, second joint about as long as first, widest at apex, apices of first and second joints fringed with short, stiff hairs, third joint long (·304), widest in the middle, with five fairly distinct annulations, arista long (·60) arising from a raised tubercle, densely clothed with short white hairs; frons wide (·45), glossy black, a few hair-like whitish scales near the depressed median line; ocellar plate prominent, occupying more than half the width of the vertex, black, rugose, with a few black hairs; vertex as wide as frons, with a few black hairs. (Figs. 7*a* and 7*b*.)



Text-fig. 7*a*, 7*b*.
Wallacea darwini, n.sp., female.

Thorax widest at insertion of wings (1·85); humeral calli pro- nent, on either side of the scutellum there is a prominent disc- te process (prealar callus) projecting (·15) horizontally from e thorax; scutellum large, (·75 long), triangular, armed with o long (·30), stout, apical spines (generic character), and about en somewhat irregular and smaller stout spines on either side, patch of silvery scales near apex. The whole upper surface of rax and the pleura clothed with moderately short, stout, black hairs and narrow silvery scales, the latter giving the appearance of silvery dusting; sternum clothed with silvery hairs; the entire thorax and abdomen minutely punctured. Wings hyaline, principal veins thickened, the three posterior veins all reaching the wing border. Halteres with brownish stem and stramineous knob (Fig. 7*c*).



Text-fig. 7*c*.
Wallacea darwini, n.sp., female.

Legs: forelegs black, excepting joints and proximal ends of tibiæ, which are brownish, tarsi densely clothed with short, stout, black hairs; mid-legs black, excepting apices of femora and the first four joints of the tarsi, which are ochraceous, fifth joint and claws dark, tarsi clothed with short, stout, black hairs; hind-legs similar to mid-legs. Pulvelli and empodia large.

Abdomen wide (2·75), wider than long, clothed with black hairs (silvery in some lights), a conspicuous patch of silvery scales on the dorsum of the fifth segment, except in the median line, simila but fewer scales on dorsum of fourth segment, nearly absent from third segment, a smooth bare patch in the middle of the anterio margin of the fourth segment, wider and occupying the whole o the middle of the fifth segment. Genitalia conspicuous.

♂. Similar to ♀. Total length, 3; wing, 3.

Head wide (1·25), wider than prescutum (1·15), frons wid (·320).

Thorax 1·30 at insertion of wings.

Legs similar to ♀, excepting that the tarsi of mid-legs ar ochraceous. Halteres brownish, knob white.

Hab.—Northern Territory: Darwin, June, 1918. Both speci were taken on a citrus leaf.

(*Note.*—This genus has not been recognised hitherto in Au tralia.)

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THE METABOLISM OF WHITE RACES LIVING IN THE TROPICS

II. THE COMPOSITION OF THE URINE

BY

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In the course of a study of the effects of a tropical climate upon a white working race, a number of urines have been analysed to ascertain whether they showed any marked variation in the quantities of constituents from those given in the physiological text-books as the average excretions for dwellers in a temperate climate.

Investigations on the urine of white men living in the tropics have previously been carried out by a few workers only, and these have been done mostly with the object of inquiring whether the changed conditions bring about an altered mechanism for regulating the thermal equilibrium of the body.

The only systematic work of any extent is that of Eijkman (1893), in Java, who estimated the calorific value of the food of nineteen Europeans, and drew up a balance sheet between the nitrogen of the food and that excreted in the urine and faeces. In the course of these experiments he analysed the daily urine of his subjects over a period of fourteen days.

A few workers have recorded the results of observations upon themselves made during a short visit to the tropics, and have compared these with figures obtained in Europe before or after their journey. Among these latter may be mentioned Schilling and Jaffé (Schilling (1909)), who compared the composition of the diet taken by themselves in Europe with that consumed during a short stay in West Africa; in addition they determined the nitrogen excreted in the urine and faeces in both places. Rancke (1900), Wick (1910), Glogner (1909), and a few others have also published the results of a few observations made on themselves.

The results have been recorded of the examination of the urine of a number of American soldiers serving in the Philippines, as well as of natives of these islands, but these observations have been mainly confined to volume and specific gravity (Chamberlain (1911)).

A certain amount of work has been done on the composition of the urine of native races in the tropics. Eijkman (1893) analysed the urine of a few Malays for comparison with his Europeans, whilst McCay (1912) has recorded observations on a large number of urines of Bengalis, and Aron (1909) has examined urines of natives in Manilla. More recently Campbell (1917) published the results of analyses of the daily excretion of a few native medical students in Singapore. In most instances it was found that the urines of natives showed marked differences from the European standards, thus, for example, the nitrogen was generally much lower, which may be accounted for by the native diets being generally poorer in protein, and richer in carbohydrate than the diet usually consumed by the white man.

The results of these previous investigations will be discussed in reference to those recorded in Townsville in the following pages.

In a previous publication (Young (1915)) the results were recorded of an investigation carried out in Townsville into the partition of nitrogen amongst the various nitrogenous constituents of the urine. It was found that the total nitrogen in the urine was somewhat low, but the proportions of this nitrogen in the individual compounds agreed approximately with those found elsewhere.

It is a common belief that in the tropics the excessive loss of water through the skin causes a corresponding decrease in volume of the urine, and that the continued passing of concentrated urine is responsible for a large amount of kidney disease. In the present investigations, therefore, the main object has been to compare the concentration of urine with that found in Europe, and attention has been confined to the volume, specific gravity, total nitrogen, freezing point (osmotic pressure) and certain inorganic constituents.

METHODS

The following methods were employed in these experiments. The specific gravity was determined at 15° C. with a Mohr's balance, the total nitrogen by Kjeldahl's method, and the sodium chloride by Volhard's method, i.e. by adding a known amount of silver nitrate, filtering off the silver chloride, and estimating the silver nitrate left unchanged by titration with potassium sulphocyanide in presence of a ferric salt. The phosphate was determined by titration with a uranium solution. The freezing point of the urines was obtained in the usual manner.

The results are put together in the accompanying Table 1, all the figures being obtained during the hot summer months. The subjects were drawn from various walks in life, and comprise persons doing laboratory work, a medical man in practice, a newspaper reporter, hospital wardsmen, several men doing office work in the city, a shop assistant and several labourers. The figures in the table refer to the whole urine passed in twenty-four hours, the subjects living on their ordinary diet.

As is well known, with a freely chosen diet considerable variations are observed from day to day in the quantity of the various substances excreted in the urine, so that no great accuracy can be claimed for a single twenty-four hours' sample. The following figures, however, were found for a number of persons of very different occupations, and it will be noticed that on the whole they vary from the usual standard in the same way, so that the average figures may be taken as an indication of the type of urine found in tropical Australia.

Table I.

Subject	Volume c.c.	Specific Gravity	Total Nitrogen grams.	Grams		Freezing point degrees C.	P_2O_5 grams.
				Sodium Total	Chloride per 100 c.c.		
1 (*a*)	1116	1·016	8·7	6·14	0·55	1·028	...
(*b*)	1000	1·017	7·8	3·60	0·32	0·935	...
(*c*)	525	1·027	8·0	3·60	0·68	1·726	...
(*d*)	515	1·026	6·8	4·75	0·92	1·907	...
2 (*a*)	830	1·023	10·2	5·41	0·65	1·437	...
(*b*)	644	1·023	8·0	3·69	0·57	1·466	...
3 (*a*)	885	1·025	11·0	8·15	0·92	1·643	...
(*b*)	814	1·032	14·7	6·95	0·85	2·095	...
4 (*a*)	718	1·030	10·9	8·55	1·19	2·049	...
(*b*)	753	1·031	11·7	10·32	1·37	2·102	...
5 (*a*)	624	1·032	9·8	6·73	1·08	2·119	...
(*b*)	556	1·031	...	4·50	0·81	2·025	...
6	965	1·026	11·7	12·35	1·28	1·869	...
7	582	1·028	6·5	6·29	1·08	1·694	...
8	874	1·027	15·0	4·82	0·55	1·929	...
9	738	1·031	14·3	5·64	0·76	2·105	...
10	852	1·024	11·7	6·69	0·79	1·714	...
11	702	1·023	9·2	5·68	0·81	1·675	...
12	875	1·021	9·7	8·85	1·01	1·613	1·24
13	593	1·022	6·9	7·24	1·22	1·752	1·57
14	1390	1·023	15·6	15·37	1·06	1·748	0·81
15	634	1·031	11·6	5·41	0·85	2·259	2·61
16	905	1·027	12·7	8·94	0·99	1·970	2·24
17	920	1·020	8·9	7·65	0·83	1·581	2·06
18	688	1·026	10·8	6·03	0·88	1·987	1·34
19	655	1·025	8·7	5·59	0·85	1·611	2·04
20	375	1·018	3·1	2·95	0·79	1·360	0·57
21	718	1·026	9·6	6·78	0·94	1·925	1·86
22	1070	1·024	14·3	10·38	0·98	...	2·61
23	922	1·027	12·4	12·76	1·32	...	1·76
24	782	1·025	10·8	7·38	0·94	...	1·96
25	621	1·023	8·8	5·00	0·49	...	1·56
Mean ...	782	1·0254	10·4	7·0	1·13	1·761	1·73
Maximum ...	1487	1·032	17·3	15·4	1·39	2·259	2·61
Minimum ...	375	1·013	3·1	2·95	0·32	0·935	0·57

22, 23, 24 and 25 are the averages over one week in each case.

The total volume, specific gravity, and inorganic salts

The figures given in the text-books (Starling (1912)) as the average for temperate climates are:—

	European	Townsville averages
Volume c.c.	1500	782
Specific Gravity	1·014 to 1·020	1·0254
Freezing point	–0·87° to –2·71°	–0·935° to –2·259°
Sodium Chloride	15·0 grams	7·0 grams
Phosphate	2·5 grams	1·73 grams

When compared with these it is seen that the volume is very considerably lower, the average being only 782 c.c. per day. The gravity is correspondingly higher. The freezing points of the urines come in every case within the range given for temperate climates, the maximum being – 2·259° C. with a mean depression of 1·76° C.

The sodium chloride shows a very interesting difference. The quantity was in every case but one (No. 8) far below the European figures. The average amount passed was found to be only seven grams per day. When the actual concentration of this salt is considered it is seen that it is not very different from that found in temperate climates, namely about 1 or 1·2 per 100 c.c. The figures actually found vary from 0·32 to 1·39 grams per 100 c.c. with an average of 1·13. This small amount of salt in the urine is thus instrumental in maintaining the freezing point about the same as that found in Europe. The small total quantity of chlorides present in the urine may be accounted for by the excessive perspiration, and a quantity of sodium chloride being excreted in this way.

The amount of water and sodium chloride lost in the sweat

The quantity of water lost in perspiration in the tropics is very considerable. Eijkman (1893) estimated that in his subjects, laboratory workers, an average of 1730 c.c. was lost per day in the perspiration and from the lungs. This, however, seems a small amount for a man doing manual labour in a hot climate such as that of North Queensland, and where all the work is carried out by white people, who work mostly to the same hours as in a temperate climate, that is during the hottest part of the day. Hunt (1912) in a paper upon the effects of a dry hot climate upon the body, describes his experiences during a march in the Deccan in India, with the dry bulb temperature at 104° F., and states that none of his party consumed less than three gallons (13·6 litres) of water per day, a quantity which he considers as the minimum advisable. He states that even with this quantity of liquid the flow of urine was by no means free. Most of this water, therefore, must have passed out by the skin and lungs.

In a warm moist climate, where there is little evaporation, the slightest exertion causes profuse sweating, and this saturates and clogs the clothing, and thus further interferes with free evaporation from the skin. This induces further excretion of sweat, a sort of vicious circle is set up, and the body is not able to utilise the sweat economically. The result of an increased consumption of water is an increased perspiration, which adds to the discomfort, and it is only when a very large amount of water is taken that any marked increase in the quantity of urine is observed. In spite of this discomfort the slightest exertion causes an increased desire for liquid, and a large quantity of water is consumed, and thus a corresponding amount of water is excreted by the skin.

In some experiments carried out in Townsville the loss in body weight was observed during a brisk walk of seventy minutes at the rate of about four miles an hour, the thermometer at the time being 80° to 85° F. dry bulb, and 70° to 80° F. wet bulb. The loss of weight in some subjects reached as much as 1100 grams, most of which would be due to loss of sweat. Moreover, in these experiments only the water actually evaporated was determined, the subjects being weighed in their clothing, which was saturated with sweat, so that the total loss of water must actually have been much greater than this quantity.

Losses of water such as this must be quite a common occurrence with people doing manual labour in the tropics. In discussing this question with a local carpenter, the author was informed that in the workshop it is customary for the men—four in number—to fill in the morning a large bucket, capable of holding nine to ten litres, with water, and from time to time during the day these men dip their pannikins into it and drink. The whole contents of the bucket are consumed during the day, and it generally has to be replenished before the day's work is over. In addition these men will drink a large amount of tea and other liquids outside and at their homes. The great bulk of this water must be excreted in the sweat. It seems probable, therefore, that with manual work at least four or five litres of water per day must be passed through the skin.

With four workers in the laboratory the amount of actual liquid taken in was found to average between three and four litres per day per man, whilst the average volume of urine passed was only 817 c.c.

In order to estimate the quantity of sodium chloride which may be removed from the body in the sweat, determinations of this salt were made in the sweat of two subjects. The sweat was collected in a room in which the air was practically saturated with moisture at 95° to 96° F. The body was well washed down beforehand, so as to remove all old sweat residues. Generally two samples collected at an interval of half an hour agreed well in the sodium chloride content, showing that under these conditions there was no concentration of sweat on the skin, and that the specimens represented a fair sample of the sweat excreted. The sodium chloride was estimated by a modification of Volhard's method.

With one subject, upon two occasions, samples of sweat were found to contain 0·36 and 0·31 grams of sodium chloride per 100 c.c. respectively. During the first experiment the subject lost 650 grams in body weight during an hour in the hot room. The loss in weight due to respiratory exchange* during this time, as

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* The loss in weight due to the respiratory exchange was calculated in one experiment. The expired air was measured by breathing into a Zuntz meter and a sample of this air was analysed for oxygen and carbon dioxide. The subject breathed into the meter for five minutes just before going into the hot chamber, again after thirty-five minutes, and a third time after seventy minutes in the chamber. The volume of CO_2 evolved and oxygen absorbed in c.cs. per minute reduced to N.T.P. were :—

	CO_2 evolved	O_2 absorbed
Before entering	197	216
After 35 minutes	294	327
After 70 minutes	311	375

An average of these rates over the whole time gives as a rough estimate 19 litres of CO_2 evolved and 22 litres of O_2 absorbed, i.e. a total loss of about 7 grams in weight.

well as the loss in water from the lungs with the inspired air saturated at 96° to 97°, may be neglected, so that the loss of weight represents loss by sweat. The sodium chloride excreted in the sweat during this time was thus 2·34 grams.

Samples of sweat from a second subject were collected under the same conditions, and were found to contain 0·22 grams of sodium chloride per 100 c.c. During the hour and a half which the subject spent in the hot chamber, he lost 2,000 grams in weight, corresponding thus to 4·4 grams of sodium chloride from the skin. In another experiment on this subject the sweat was found to contain 0·11 grams of sodium chloride per 100 c.c.

Hunt (1912) found that his sweat contained 0·18 to 0·20 grams per 100 c.c., and he obtained higher figures (0·4) with other subjects. The quantity of sodium chloride excreted in the sweat may therefore be taken as from 0·1 to 0·4 grams per 100 c.c. A daily loss of sweat of several litres would, therefore, correspond to a good many grams of sodium chloride, and the deficiency of this salt in the urines under examination (7 grams instead of 15) may easily be accounted for by increased excretion by way of the skin.

The fact that so much sodium chloride is excreted in the sweat does not mean that the kidneys are relieved of any work, but rather the other way, since this salt after passing from the blood through the glomeruli of the kidney must have been subsequently reabsorbed in the tubules of that organ.

The phosphates

The quantity of phosphates expressed as phosphoric acid averaged 1·73 grams per day with a maximum of 2·61 and a minimum of 0·57. The normal figure given by the text-books is 2·5 grams, so that the phosphate was slightly lower than the standard. The concentration of phosphate was, however, much higher than the standard, 0·25 grams per 100 c.c. as against 0·17 grams. In samples of urine collected here, it is a common thing for phosphates to separate out within a very short time after the urine has been passed, and in many cases the urine is actually voided in a cloudy condition, which is due to precipitation of the phosphates, since it clears at once upon the addition of acid.

The total nitrogen

The urines examined in Townsville gave an average daily figure of 10·4 grams of nitrogen. Considerable variations were found in the same individuals at different times. In the following table are seen the daily averages of the nitrogen secreted by four persons over different periods :—

Subject	Date	Days	Volume	Specific Gravity	Nitrogen
1	March, 1913	9	986	1·026	11·7
	December, 1913	8	772	1·030	11·6
	February, 1914	7	1070	1·027	14·3
	January, 1915	7	849	1·026	12·4
	Average ...				12·1
2	September, 1914	4	922	1·029	12·4
	January, 1915	4	735	1·030	11·2
	Average ...				11·8
3	March, 1913	7	621	1·026	8·8
	January, 1915	7	946	1·025	7·8
	March, 1917	7	667	...	9·2
	Average ...				8·6
4	April, 1914	7	782	1·025	10·8
	January, 1917	4	737	1·023	9·1
	Average ...				10·1

Although in these four cases the average nitrogen differed fairly considerably from time to time, yet in general it was markedly lower han the European average, the mean of all four persons being 0·6 grams per day.

The figures all point to the fact that the nitrogen is below the European standard.

Urines collected during the cool season

Northern Australia has a hot and a cool season, and during the atter (May to October) very different climatic conditions are observed, the wet bulb thermometer is much lower and occasional spells of what is felt by the inhabitants to be cool weather are experienced. A few urines have been collected during this season for comparison, and these are given in the table below, the numbers being the averages of urine collected for several days.

Table II.

	No.	Volume c.c.	Specific Gravity	Total Nitrogen grms.	NaCl. grms.	NaCl. per cent.
	1	1437	1·017	12·1	...	...
	2	1037	1·021	11·7	...	...
	3	1372	1·012	10·5	...	...
	4	1367	1·014	11·0	...	...
	5	1214	1·016	9·5	9·87	0·80
	6	1912	1·016	14·5	9·95	0·59
	7	1766	1·018	7·9	8·24	0·72
	8	1441	1·020	9·4	13·58	0·97
	9	878	1·027	10·2	9·15	1·07
	10	1151	1·015	9·7	5·86	0·48
Average	5-10	1357·5	1·0187	10·2	9·44	0·77
Same subject hot Season		770	1·0257	9·95	6·55	0·86

These figures show a decidedly larger volume and smaller gravity than those obtained in the hot season, whilst the sodium chloride is larger in amount, but less in concentration. The urines of the last six subjects are averaged separately in the table for comparison with those of the same subjects during the hot season.

DISCUSSION

The records in the literature of the composition of the urine passed by the white man in the tropics are not very plentiful, and often contradictory in the results obtained.

Eijkman (1893) found that his nineteen European subjects in Java over fourteen days gave the following daily averages:—

Volume 1,442 c.c., specific gravity 1·017, nitrogen 13·04 grams. These urines, therefore, did not differ to any marked extent from those found in Europe as regards concentration, volume and nitrogen. Other workers have recorded the results of observations on themselves. Thus Plehn (1908) in West Africa found that his urine had an average daily volume of 1,075 c.c., and a specific gravity of 1·025, whilst Glogner (1909) found the volume practically identical in Sumatra and Berlin.

Neuhaus (1893), during a journey round the world in 1893, tested the average volume and gravity of the urine which he passed daily at various places during his journey. In the tropics the volume varied from 1,100 to 1,200 c.cs., and the specific gravity from 1·029 to 1·033, whilst outside the tropics the volumes ranged from 1,353 to 1,609 c.c., with a gravity of 1·021 to 1·023. His urine was thus more concentrated in the hotter parts of the world.

Chamberlain (1911) took the gravities of single specimens of urine of five hundred and ninety-six soldiers in the Philippines upon two occasions at a year's interval, and he obtained the figures 1·099 and 1·097. He concluded that the urine was therefore little different in gravity from that found in a temperate climate.

In a recent research Campbell (1917) found that his own urine in Singapore conformed in volume and gravity to the European standard, being 1,560 c.c. and 1·012 respectively. It is noteworthy in the last instance that the sodium chloride content averaged only 8·10 grams, or 0·52 per cent.

When the averages found in Northern Australia are compared with the figures quoted above, it is seen that they differ in that the volumes obtained elsewhere were much higher than those recorded in Australia, whilst the specific gravities were generally lower.

A comparison of the nitrogen with that found in Europe and by other workers in the tropics shows also certain differences. Our ideas of the metabolic changes which the protein taken in the food undergoes in the animal body have altered considerably in the last decade. The modern view assumes that the proteins are broken down by the digestive enzymes of the intestines into their constituent amino acids, which are then absorbed. The greater part of these are denitrified, the bulk of the nitrogen being quickly eliminated in the urine as urea. A small portion goes to make good the wear and tear of the tissues. The nitrogen in the urine represents, therefore, mainly the substances produced directly from the proteins of the food (exogenous metabolism, Folin), which vary in quantity with the amount of food taken. In addition it contains the nitrogenous substances such as creatinine produced by metabolism of the tissues (endogenous metabolism, Folin), which, according to Folin, are not materially different in quantity whether the diet is rich or poor in protein. The nitrogen in the urine is not an accurate measure of the quantity of protein metabolised, since a certain quantity is excreted into the intestine and passes out with the faeces, a certain quantity may be retained in the body, and a small amount is also lost in other secretions of the body such as the sweat. Still the total nitrogen in the urine may be taken as a rough indication of this protein.

In ordinary life when an indiscriminate diet is consumed, naturally great variations occur from day to day in the quantity of nitrogen passed in the urine, but the average figure as given in the text-books on physiology for temperate climates is about 15 or 16 grams of nitrogen per twenty-four hours.

Pflüger and Bohland, and Bleibtreu and Bohland (quoted by Eijkman) give rather less than this, namely 12·67 and 14·93 grams per day.

With regard to the nitrogen in the urine of white people in the tropics, Eijkman found that the urine of his nineteen European subjects on an ordinary mixed diet contained a daily average of 13·04 grams. He concluded, therefore, that an acclimatised European in the tropics passed as much nitrogen in his urine as he did in Europe.

Schiller and Jaffé (Schilling (1909)) during a short visit to West Africa, carried out experiments on themselves, and compared these with observations made in Europe before and after their journey. They found that in both parts of the world nitrogen equilibrium was approximately maintained on 17 grams of nitrogen a day, so that no appreciable difference was observed in the urine nitrogen.

Similarly Campbell (1917) in Singapore found that his own daily urine contained on the average 15·3 grams of nitrogen, similar again to the European standard.

These results would indicate that the quantity of protein required in the tropics is not different from that consumed elsewhere, and in fact Eijkman's analyses of the food eaten by his subjects, conformed in every respect to the usual standards. A similar conclusion was also arrived at by other researchers.

On the other hand Ranke (1900) published a comparison of his own diet during a visit of a few months to Brazil. This diet showed that although the protein was not much different, yet the total calorific value was much less in the tropics than in Europe. Glogner explained Ranke's observations as probably due to a loss of appetite, which he states is a common experience during the first period of residence in the tropics, and he concluded that Ranke had not resided in the tropics long enough to have passed this stage.

With regard to the nitrogen in the urines analysed in Townsville the average obtained was very much lower than that of the European text-books, and did not agree, therefore, with the results recorded by others in the tropics.

A certain difference in the nitrogen might be expected in a hot climate, on account of the larger quantity of water excreted by the skin, which takes with it a small quantity of nitrogen. Eijkman found the nitrogen lost in this way by Malays to be about 0·76 to 1·36 grams, and he estimated that Europeans in Java lost about 1·6 grams per day.

Benedict (1906), outside the tropics, found that during rest the nitrogen secreted in the sweat was approximately 0·071 grams per day, but during muscular exercise he found as much as 0·13 to 0·22 grams per hour.

In experiments carried out in this laboratory and already referred to, samples of sweat were obtained and determinations were made of the nitrogen in them. This was found to be 0·040 and 0·057 grams per 100 c.c. upon two occasions in one subject, and 0·033 and 0·030 grams per 100 c.c. in the other; the two subjects thus lost only 0·26 and 0·66 grams of nitrogen respectively during an hour in the hot chamber.

Allowing a man to lose from three to four litres of water a day by way of the skin, this would only account for a daily loss of 1 to 2 grams of nitrogen by this means. If this be allowed for it would bring the average nitrogen to from 11 to 12 grams per day, and a further allowance of 10 per cent. lost in the faeces would bring the total to about 13 to 13·5 grams, which, taking the higher figure, corresponds to about 87 grams of protein, a figure still below that usually accepted as a standard (viz., about 100 grams (Voit)).

Eijkman found that his subjects in Java consumed on an average 99·6 grams of protein, of which 88·2 grams were actually absorbed, the rest being lost in the faeces. Taking Eijkman's average figures for nitrogen in the urine, 13·04 grams, and making the above allowances for sweat and loss in the faeces, it works out at about 101 grams protein per day, a number in close agreement with that found. It would appear, therefore, that with the subjects experimented on in Townsville the protein actually katabolised was less than that found by Eijkman in Java.

When an explanation is sought for these different results, a possible one suggests itself in the different conditions under which life is carried on in the Australian tropics. Eijkman's subjects, for example, were living in Java, where cheap native labour is to be obtained in abundance, and it is the rule to rest during the early and hot portion of the afternoon. In Queensland, on the other hand, as has been pointed out already, work is carried on by white people, and it is the exception to rest during the hotter hours of the day.

The results of examinations of the urine of native races in the tropics show differences from that of white people. As a rule, the native consumes less protein and more carbohydrate than the white man, and as might be expected, therefore, the urines are lower in nitrogen. Eijkman found that the daily urine of thirteen Malays gave an average of only 8·08 grams of nitrogen. Campbell, for native medical students in Singapore, obtained figures varying from 6·64 to 9·25 grams of nitrogen per day. On the other hand, Aron, in the Philippines, found a higher number, the nitrogen in the daily urine of the Philippino being stated to vary from 10 to 12 grams.

McCay (1912) has made a large number of observations upon the urine of Bengalis in India, and has compared them with the standards for Europeans. Very decided differences were found to exist, as is seen in McCay's table which is given below. However, if the Townsville urines be placed side by side with this table, the differences from the European standards are almost as striking for some constituents as those given for the Bengalis. The urea and sulphate given below were obtained from five people, and are the daily averages for a week in each case.

TABLE III

	European	Bengali	Townsville
Volume c c.	1440	1200	784
Specific gravity	1020	1013	1025
Urea grams	35	13	20·7
Total nitrogen grams ...	18	6	10·4
Freezing point	−2·5° C.	−1·24° C.	−1·76° C.
Chlorides grams ...	15·00	10·00	7·53
Phosphates grams... ...	3·50	0·98	1·73
Uric acid grams	0·75	0·45	0·48
Sulphates grams	2·50	1·88	2·01

The average daily excretion of nitrogen found in Townsville (10·4 grams) may be compared with that obtained by Chittenden (1911) from one hundred and eight university students in the United States, the average daily nitrogen in the urine being 12·87 grams.

It is interesting also to compare the samples for one week obtained from four men doing laboratory work in Townsville with those averages given by Hamill and Schryver (1906) for seven men doing similar work in the laboratory of University College, London.

	Weight kilos	Total N. grams
1	67	14·3
2	61	12·4
3	63	10·8
4	48	8·8
Average	59·8	11·6
Schryver and Hamill	72·4	13·5

Although the average nitrogen is actually less in Townsville, yet when considered per kilogram of body weight the figures are practically the same (0·194 and 0·186 grams), and both correspond to an amount of protein very much below what used to be considered as the daily standard (approximately 100 grams of protein), even when all due allowances are made for the nitrogen lost in the faeces.

ALBUMINURIA

It has frequently been stated that the higher concentration of the urine in the tropics causes a greater amount of kidney disease than is found in temperate climates; moreover, in the opinion of many medical men in Northern Australia, a greater incidence of kidney troubles is found there. As reliable figures to test this could not be found, an attempt was made to obtain some indication by ascertaining the prevalence of albuminuria in Townsville.

A number of samples of urines from out-patients of the General Hospital were collected and tested for the presence of albumin. In no case did the subject show any other clinical symptoms of kidney trouble. The tests employed were the boiling test, the salicyl sulphonic test and the ferrocyanide test, and no urine that did not give all these tests was accepted as definitely containing albumin. The urine from six hundred and sixty-three patients was examined, including three hundred and sixty men and three hundred and three women, and a positive reaction was obtained in fifty-seven cases, forty-two of them being men and fifteen women. This would correspond to a total percentage of 8·6; amongst the men the percentage was 11·7, and amongst the women 4·9.

No attempt is made to draw any conclusions from these figures, but it is thought of interest to put them on record. The much higher percentage amongst men than women is worthy of note, nineteen out of forty-two of the cases in males being in men above the age of forty years.

SUMMARY

The twenty-four hours' urine collected from a number of persons living in North Queensland and of different occupations was analysed. The daily volume was very much less than the European standards given in the text-books, the average volume being only 784 c.c. This volume was increased considerably in the cooler weather.

The specific gravity was very much higher, whilst the freezing point did not differ very much from that found in Europe, thus the osmotic pressure was not very much higher.

A striking difference was noticed in the quantity of sodium chloride excreted in the urine, which was very low, and this may be accounted for by the large loss of water in the sweat which carries with it this salt. It is calculated that a man doing manual labour in the tropics must lose several grams of sodium chloride per day through the skin, which would readily account for the deficiency in the urine.

The total nitrogen showed a lower figure than that found in Europe, which cannot be accounted for by loss of nitrogen from the skin, since it is shown that this can only amount to 1 or 2 grams per day under normal circumstances.

These results differ from those obtained by Eijkman and other observers in other parts of the tropics.

An examination of the urine for albumin of persons not showing any other symptoms of kidney disease showed a high percentage of albuminuria, which was more marked in men than in women.

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NOTES ON THE BIONOMICS OF *STEGOMYIA FASCIATA*, FABR.

(PART I)

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INTRODUCTION

Since the discovery of the rôle of *Stegomyia fasciata* in the transmission of yellow fever, much attention has been devoted to the study of the life history and habits of this mosquito in Europe, Africa and America.

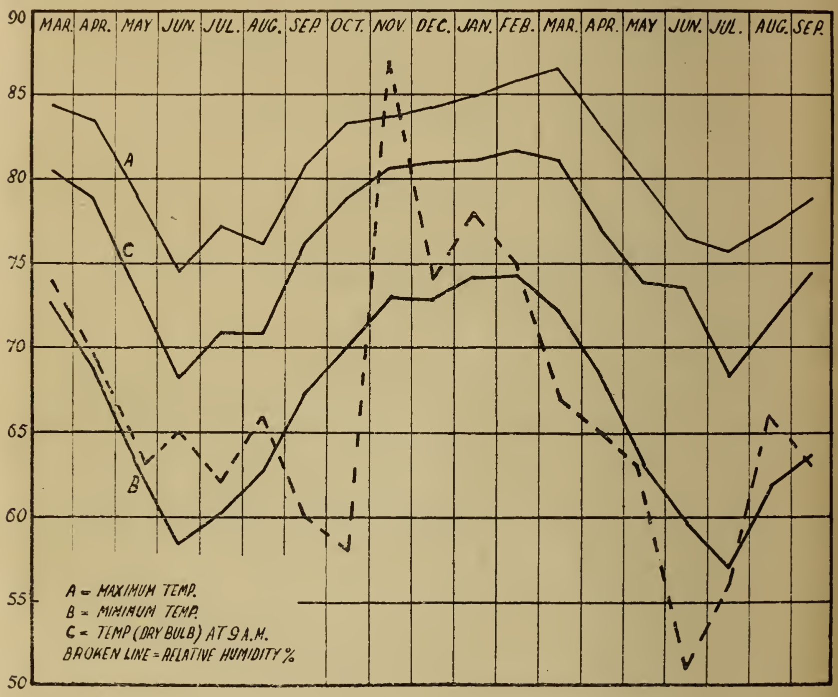
Notwithstanding the vital importance of such knowledge to Australia, no research work of any importance, other than Taylor's inquiry into the distribution of the species in the coastal towns of Queensland, has been undertaken in Australia, either to confirm or to supplement the result of investigations carried out elsewhere by Finlay, Goeldi, MacGregor, Carrol, Reed, Newstead, Boyce, Bacot and many other workers, to whom we are indebted almost entirely for our knowledge of the bionomics of this widely distributed species.

The necessity for breeding large numbers of *Stegomyia fasciata* to meet the requirements of this Institute appeared a favourable opportunity to undertake some of this hitherto neglected work. Although very incomplete, it has been considered advisable to record the results of these observations and experiments at this stage, rather than to defer their publication until further contemplated experiments have been undertaken.

It will be observed that where similar information has been sought, I have followed very closely the methods and technique of Bacot (1916), whose paper has been freely consulted, as being by far the most complete and comprehensive of its kind yet published.

The various stages of *Stegomyia fasciata* have been so fully and accurately described by earlier writers that it is quite unnecessary to attempt to add anything to their descriptions, nor can new facts be added regarding the seasonal prevalence and distribution of this mosquito in Townsville to the published records of Taylor (1915).

The accompanying chart shows the temperatures and humidity readings taken in the Institute grounds during the period in which the experiments were carried out.



METHODS OF KEEPING AND FEEDING ADULT MOSQUITOES

In these experiments the adult mosquitoes were kept in small cages, as commonly used, measuring 12 by 8 by 7 inches, and consisting of a light wooden frame covered with cheese cloth on three sides and one end, and zinc on the bottom. The remaining end was fitted with a calico sleeve sufficiently large to permit of the passage of the arm and necessary water containers. A glass panel occupied one-third of one side of each cage, but it was considered to be of no advantage when light fabric was used for screening the remainder of the cage. The mosquitoes were offered food daily, the following substances being tried at different times, viz., blood, banana, peptone and sugar solution, milk and sugar, etc. After some initial trials blood was found to be the most satisfactory for the females and banana for the males, these foods being used subsequently to the exclusion of all others.

Feeding experiments with small animals, such as guinea-pigs, rats and puppies, were, as a rule unsuccessful, even when the animal was left in the mosquito cage overnight. The most satisfactory method of feeding with blood, and the one adopted throughout the following experiments, was found to be the presentation of the arm and hand each morning for a period of from ten to twenty minutes according to circumstances, it being noticed, for example, that during hot and humid weather the mosquitoes fed more readily than in cool weather.

In some current experiments, in which it is desired to feed *Stegomyia* on dog's blood, successful results are obtained by the following method:—One of the cages previously referred to is placed upon the floor and the dog's head thrust into it, the animal being kept in a recumbent position and the sleeve of the cage secured behind its head with one hand whilst the other presses the body to the floor to prevent the animal rising. To ensure successful feeding it is found necessary to shave or clip the hair on the face and ears. Other methods of feeding upon dogs were tried, but found to be unsatisfactory.

I. EGGS

The maximum number of eggs laid by a fertilised captive female

From a long series of observations it has been found that the verage egg production of a fertilised captive female fed on blood s about seven hundred and fifty, covering a laying period of from orty to seventy-two days. None of my records cover a longer eriod of productiveness, although females have been kept in aptivity up to a maximum of ninety-three days. It was found npossible, however, owing to absence from Townsville, to continue blood feeding after the sixty-sixth day, banana being substituted for blood, with the invariable result that egg production ceased on the change of food.

The following record may be cited as typical of many illustrating the rate of egg production. A female, bred for five generations in the laboratory, was segregated with two males and fed exclusively on human blood. The first feed was taken four days after her emergence, and the first batch of eggs laid three days later. During the first thirty-one days of her life she fed eight times and laid four hundred and thirty-seven eggs. During the succeeding thirty-one days she fed six times and laid two hundred and sixty eggs. Two more feeds were taken and fifty-five eggs laid during the following ten days. In all she fed sixteen times and laid seven hundred and fifty-two eggs during the seventy-two days of her life. On the day following the laying of the last batch of eggs she was accidentally destroyed. A complete record of these eggs was not kept to determine the percentage of fertility, but a certain proportion of the batches were kept under observation and found to produce between 80 per cent. and 90 per cent. of larvae.

The selection of situation for oviposition

(*a*) Females in captivity

The receptacles usually provided in the cages for oviposition were dishes 3 inches to 4 inches in diameter, and contained about ½-inch to 1 inch of water. The favourite position of the ovipositing female appears to be resting on the sides of the receptacle with the apex of the abdomen just touching the water. Very often eggs are laid on the surface film of the water as the female moves about on it, but occasionally as many as fifteen eggs are laid in a batch. A considerable proportion of the eggs laid near the margin of the receptacles are drawn against the sides by capillary attraction, and become stranded as the water dries. Under more natural conditions these doubtless form the bulk of the resistant eggs which lie dormant until the supply of water is replenished. When wet filter paper is provided the eggs are usually scattered over its surface, but occasionally they are laid so close together as to overlap.

(*b*) Wild females

It has been frequently noticed that almost any vessel containing water and left in or near the Institute building would attract the females of *Stegomyia* and offer a suitable place for oviposition.

In view of the opinion held by some other observers that these mosquitoes show a decided preference for certain positions and certain rooms, the investigations detailed in Experiment No. 1 were undertaken with the object of confirming, or otherwise, the results of my casual observations.

EXPERIMENT I

Position	Nature of Receptacle	Contents	*Stegomyia* eggs laid	Remarks
Workroom on floor ...	Enamel bucket ...	Tap water	+	
Workroom on bench ...	Earthenware sink ...	Tap water	+	
Vorkroom on bench ...	Pickle bottle	Tap water and sea water equal parts	+	
Vorkroom on bench ...	Pickle bottle	Rain water	+	
Vorkroom on bench ...	Tin used as water bath	Rain water	+	Also *Culex* sp.
Iallway	Glvd. iron cistern 12 ft. from floor	Rain water	+	
athroom on bench ...	Glvd. tin	Tap water	+	
athroom on floor ...	Earthenware jar ...	Tap water	+	Also *Culex fatigans.*
Vater Closet	Cast iron cistern not used for some time	Tap water	+	
terilising room on bench	Enamel bowl	Tap water and dirty tubes	+	
ter. room under bench	Earthenware jar ...	Tap water and dirty slides	+	Also *Culex fatigans* and *C. ? sitiens*
nimal house on shelf 8 ft. from floor	Glvd. iron dish ...	Tap water	+	
nimal house on shelf 8 ft. from floor	Enamel bowl	Tap water	+	
nder roof of Institute ...	Glvd. iron dish ...	Tap water	—	
nder roof of Institute ...	Glvd. iron dish ...	Tap water	—	
nder roof of Institute ...	Enamel bowl	Tap water	—	

The investigations on the whole tend to show that in Townsville, at any rate, *Stegomyia* do not appear to show a preference for certain rooms or situations, but will oviposit in almost any receptacle containing water. This finding is noteworthy in view of the fact that Bacot's experiments gave entirely different results. In a set of twelve receptacles under observation he found *Stegomyia* ovipositing in only one—a card cream jar in the kitchen. It must be noticed, however, that he found *Stegomyia* ovipositing in such positions as the following: in safe stands in gallery, in a tin bowl in yard and in tins and wooden tub in the mosquito house.

Baits to attract pregnant females

Experiments to ascertain if ovipositing females prefer contaminated water to clear

The following experiments (see Experiment II) were carried out in a cage containing a large number of *Stegomyia*, the females of which were given opportunities of feeding regularly on human blood. The glass dishes each contained 200 c.c. tap water, in addition to the organic matter, and were placed as far apart as the size of the cage would permit. Except in the case of leaves, which stood for forty-eight hours, none of the cultures were permitted to stand for more than twenty-four hours before being introduced into the cage. One trial was carried on a second day owing to the small number of eggs laid on the first.

Bacot, who carried out similar experiments, remarks: 'While the evidence of selection . . . appears definite, it is very far from being the unanimous unvarying character that might be expected from a deep-seated instinct coupled with larval needs. On the contrary, it carries with it a certain suggestion of bias on the part of the females in reference to their own tastes largely parallel, but not necessarily identical, with provision for their offspring. . . .'

It appears to me that these remarks might be fittingly applied to the results of my experiments. It might be observed, however, that sugar and water appeared to be the most attractive bait, yet it has been shown that sugar gave unfavourable results as a larvae food.

EXPERIMENT II

No.	Contents of dish	No. of eggs laid	Percentage of total	Remarks
	(1st SERIES)			
1	Tap water	30	8·6	No smell
2	Tap water plus 0·5 grm. dried mango leaf, standing for 2 days	30	8·6	Did not smell strongly
3	Tap water plus 0·5 grm. fresh fowl faeces	120	34·3	Did not smell strongly
4	Tap water plus 0·5 grm. freshly killed cockroach	170	48·5	Smelled strongly
	Total eggs laid	350		
	(2nd SERIES)			
1	Tap water	40	6·66	
2	Tap water plus 0·5 grm. dry pawpaw leaf allowed to decompose for 2 days	20	3·34	Did not smell strongly
3	Tap water plus 0·5 grm. dried cockroach	186	31·00	Slight smell
4	Tap water plus 1cc. ox bile	160	26·66	Fairly strong smell
5	Tap water plus 0·5 grm. Sodium Taurocholate	194	32·34	Fairly strong smell
	Total eggs laid	600		
	(3rd SERIES) 1st Count			
1	Tap water	14	21·5	On account of the few eggs laid the dishes were placed in the cage again on the following day and a second count was made 48 hours later.
2	Tap water plus 0·5 horse faeces ...	20	30·8	
3	Tap water plus 1 cc. urine 3 days old ...	31	47·7	
	Total eggs laid	65		
	(3rd SERIES) 2nd Count			
1	Tap water	120	24·0	Did not smell
2	Tap water plus 0·5 horse faeces ...	90	18·0	Smelling
3	Tap water plus 1 cc. urine 3 days old ...	290	58·0	Smelling strongly
	Total eggs laid	500		
	(4th SERIES)			
1	Rain water	43	20·5	At the conclusion all dishes had a very slight smell
2	Tap water plus 0·5 grm. powdered rice	40	19·0	
3	Tap water plus 10 grm. sugar	127	60·5	
	Total eggs laid	210		

Table I contains a summary of this experiment (Experiment II).

TABLE I.

Contents of Receptacles	Percentage of the total eggs laid in each series
Tap water and pawpaw leaf	3·34
Tap water (2nd series)	6·66
Tap water (1st series)	8·6
Tap water and mango leaf	8·6
Tap water and horse faeces (2nd count)	18·0
Tap water and powdered rice	19·0
Rain water	20·5
Tap water (1st count)	21·5
Tap water (2nd count)	24·0
Tap water and ox bile	26·66
Tap water and horse faeces (1st count)	30·8
Tap water and dry cockroach	31·0
Tap water and sodium taurocholate	32·34
Tap water and fowl faeces	34·3
Tap water and urine (1st count)	47·7
Tap water and fresh cockroach	48·5
Tap water and urine (2nd count)	58·0
Tap water and sugar	60·5

Experiments to determine whether Stegomyia *would oviposit on sea water*

For this purpose two buckets, each containing 4 litres of water, were exposed in a room where *Stegomyia* were fairly numerous. Bucket 'A' contained sea water drawn from the harbour, and bucket 'B' tap water from the town service pipes. The sea water was exposed continuously for a period of two months (19th April to 19th June), during which time no eggs were laid on it, whilst the other containing tap water was exposed for one month (19th May to 19th June) and was frequently visited by both *Stegomyia* and *Culex* *fatigans* for oviposition. In all, four hundred and ninety-one eggs of *Stegomyia* were laid.

A further series of experiments were then carried out to determine the amount of dilution necessary before *Stegomyia* could be induced to oviposit upon sea water mixed with rain water. For this purpose jars containing various percentages of sea water, from 10 per cent. to undiluted sea water, were exposed in one of the stock-breeding cages containing numerous females, which fed regularly on human blood. As each jar was found to contain eggs it was removed from the cage, and that portion of the experiment was considered finished. In the case of the jars containing 80 per cent. to 100 per cent. sea water, the vessels were kept under observation for a considerable period and until there was no further possibility of oviposition taking place. The results are shown in Table 2.

TABLE 2.

Number of eggs of *Stegomyia fasciata* laid on different percentages of sea water.

Percentage of sea water in rain water	Number of eggs laid	Remarks
10	?	Numerous eggs were laid but were not counted
20	?	
30	12	
40	43	
50	24	
60	28	
70	20	
80	nil	
90	nil	
100	nil	

Hatching of Eggs of Stegomyia

The period elapsing between the deposition of the eggs and the emergence of the young larvae is extremely variable. In the routine of breeding *Stegomyia* in this Institute, it has been found that the great majority of eggs laid overnight in the small dishes of water provided for the purpose hatched during the second and third day following in summer, and during the third and fourth day in winter. A certain proportion of eggs of some batches, however, do not hatch within this period, but do so after a further period of immersion, this period being, as I have ascertained, so long as four and a half months. Had further observations been made in this direction, it is very probable that the period of delayed hatching of continuously immersed eggs would have been found to be sometimes longer, since Bacot has shown that under these conditions hatching may be delayed from two to five months.

The influence of periods of drying upon the hatching of eggs

Theobald (1903) first drew attention to the fact that eggs of *Stegomyia fasciata* are capable of withstanding the effects of long periods of dessication. Since then, several others have published the results of experiments to ascertain the maximum period of viability of these eggs under various conditions of dry storage, and to elucidate the problems concerning the factors which bring about their subsequent hatching. Bacot believes that the incubation period of the eggs in Freetown is from thirty to forty hours, but that hatching of any given batch may be distributed over a lengthy period if subjected to periods of drying. The whole of the eggs of a batch may hatch as soon as they are replaced in water, or a proportion of them only may do so. Others may resist the first or second immersion and yield to a subsequent one. The principal factors which act as stimuli to hatching appear to be temperature and humidity. As he points out, a response to cooling would well serve the needs of the species in allowing of the fullest advantage being taken of the facilities for breeding in small temporary accumulations of rain water.

With the object of confirming the above observations under local conditions a number of experiments (III, IV, V) were carried out, which will be found to accord generally with the conclusions arrived at by earlier investigators.

Experiments to show the effects on eggs of drying and replacement of water

EXPERIMENT III

Twenty eggs laid overnight were placed in a tube 1½ inches in diameter, containing 15 c.c. of tap water, which completely evaporated and was replaced on the days shown.

Days	3	5	7	8	11	14	15	20	21	Total
Number of eggs hatched	2	4	...	9	2	...	1	...	...	18
Days when found dry (indicated —) ...	...	...	—	...	...	—	...	—	...	...
Days when water replaced (indicated +)	...	...	...	+	...	...	+	...	+	...

Thus eighteen eggs (90 per cent.) hatched in fifteen days and after two dryings; two eggs (10 per cent.) were found to be collapsed when examined on 24th day.

EXPERIMENT IV

Twenty-five eggs laid overnight were placed in a petri dish 3 inches in diameter, containing 10 c.c. of tap water, which completely evaporated and was replaced on the days shown.

Days	2	3	4	5	6	8	10	11	12	15	18
Number of eggs hatched	3	8	...	...	5	1	...	...	...	...	...
Days when found dry (indicated —) ...	...	...	—	...	...	—	—	...	—	—	—
Days when water replaced (indicated +)	...	...	...	+	...	+	+	...	+	+	+

EXPERIMENT IV (*continued*).

Days	20	21	23	26	28	29	32	33	34	Total
Number of eggs hatched	...	7	...	...	...	...	...	...	1	25
Days when found dry (indicated —) ...	—	...	—	...	—	...	—	...	...	...
Days when water replaced (indicated +)	+	...	+	...	...	+	...	+	...	...

Thus 100 per cent. of the eggs hatched in thirty-four days and after ten dryings and ten replacements of water.

EXPERIMENT V

Twenty-eight eggs laid overnight were placed in a petri dish 4 inches in diameter, containing 15 c.c. of tap water, which completely evaporated and was replaced on the days shown.

Days	2	3	4	5	7	9	11	13	16	17	20	22
Number of eggs hatched	6	...	13	...	...	...	...	...	...	...	...	...
Days when found dry (indicated —)	...	—	...	—	—	—	—	—	—	...	—	—
Days when water replaced (indicated +)	...	+	...	+	+	+	+	+	...	+	+	...

EXPERIMENT V (*continued*)

Days	23	25	26	27	29	31	32	34	38	Total
Number of eggs hatched	...	...	...	...	...	...	2	...	4	25
Days when found dry (indicated —) ...	...	—	...	...	—	...	...	—	—	...
Days when water replaced (indicated +)	+	...	+	...	...	+	...	+	+	...

Thus twenty-five eggs (89·2 per cent.) hatched in thirty-eight days and after thirteen dryings and replacements of water. The remaining three eggs were found to be uncapped on the thirty-ninth day, but no larvae were seen. Assuming that these three eggs were uncapped by larvae, 100 per cent. of the eggs in this experiment may be said to have hatched.

The viability of eggs after long periods of dry storage

The longest period during which the eggs of *Stegomyia fasciata* are known to have remained viable in dry storage appears to be two hundred and sixty-two days (Bacot (1916)). For his experiment, Bacot collected eggs laid in Sierra Leone in January, from whence they were sent to England and immersed on 20th October. Within two hours of immersion the eggs hatched freely.

The possibility of the change of climate and environment influencing the period of viability, as shown by Bacot's experiment, suggested the desirability of carrying out some experiments wholly in Townsville. In one test (Experiment VI) eggs were kept in a viable condition in dry storage for a period of two hundred and fifty-seven days. In two other tests eggs retained their viability for over two hundred days (216 and 218), and in five other tests for over one hundred and fifty days (198, 172, 169, 163, 154). The eggs used in Experiment VI were taken from the stock-breeding cages and were known, from other experiments, to be of normal fertility. Those in 'A' were stored on a shelf in the laboratory, excepting in the case of 'A' 7, which was placed between the iron roof and the ceiling of an upstairs room of the Institute building. The eggs used in 'B' were stored on a layer of sand on the roof of an out-building, where they were protected from the rain by a flat sheet of iron resting on four legs about 18 inches high. Since Bacot and others have shown that in order to withstand long periods of drying eggs must pass through a preliminary incubation period in contact with water, all the eggs used in 'A' and 'B' were incubated as shown in Experiment VI.

EXPERIMENT VI

A. INDOORS.

No. of ggs laid	Date of laying	Maximum possible time in contact with water before storage	Nature of storage receptacles	Date of immersion	No. of eggs hatched after immersion	Viable for days	Percentage of eggs hatched
		Hours.					
24	30.4.17	25	Muslin covered petri dish	28.8.17	14	120	58·3
25	1.5.17	27	Muslin covered petri dish	28.8.17	2	119	8·0
154	5.5.17	33	Muslin covered tube ...	28.8.17	32	114	20·8
68	8.5.17	35	Glass covered petri dish	28.10.17	33	172	48·5
92	13.5.17	40	Glass covered petri dish	28.10.17	40	167	43·5
61	23.5.17	91	Glass covered petri dish	28.12.17	32	216	52·4
200 prox.)	29.4.17	113	Glass covered petri dish	11.1.18	2	257	1·0 (approx.)

B. OUTDOORS.

41	7.4.17	43	Muslin covered tube ...	28.8.17	25	142	60·9
108	4.5.17	41	Muslin covered tube ...	28.8.17	25	115	23·15
70	17.5.17	40	Gelatine capsule	28.10.17	29	163	41·4
44	23.5.17	113	Muslin covered tube ...	28.10.17	2	154	4·5
62	2.6.17	138	Glass covered dish ...	11.1.18	1	218	1·6
110	23.6.17	109	Muslin covered dish ...	11.1.18	1	198	0·9

In a further series of experiments to determine the maximum period of viability after long periods of drying, thirty-two batches of eggs, numbering from thirty to one thousand, were stored for periods varying from three hundred and ninety-one days to five hundred and seventy-nine days and then subjected to stimuli to induce hatching. In all of these experiments negative results were obtained.

Resistance of eggs to drying over Calcium chloride

A number of experiments were carried out to determine the effect of Calcium chloride on eggs. Apparently this method of drying was too severe. The results are shown below:—

Eggs dried for 7 days ... 80 to 90 per cent. of the eggs hatched.
,, ,, ,, 19 ,, ... 8 to 15 per cent. ,, ,, ,,
,, ,, ,, 26 ,, ... None hatched.

Stimuli to the hatching of resistant eggs

Cooling of resistant eggs as stimulus to hatching

Bacot has shown that a rapid fall of a few degrees in temperature acts as a decided stimulus to the hatching of eggs which have been dried and have resisted subsequent immersion, or which have resisted the influence of the addition of fresh water.

In Experiment VII will be found the results of investigations which appear to fully confirm the first of these findings, although in these the eggs were not first subjected to periods of wetting and drying. In this experiment eggs were collected from the stock-breeding cages and kept in water until placed in the ice chest. Those eggs which failed to hatch within three days were considered to be 'overdue,' this 'overdue' period being shown below. Just before cooling, the eggs were placed in a dish containing 200 c.c. of tap water and removed to the ice chest, where they remained from two to forty-eight hours as shown, the temperature falling from about 80° F. to between 51·8° and 57·2° F.

EXPERIMENT VII

Eggs laid	Cooled	Days Overdue	No. of eggs	No. hatched within 2 hours	No. hatched within 24 hours	No. hatched within 48 hours	Percentage hatched
25.3.17	3.4.17	6	6	6	...	...	100·0
13.4.17	24.4.17	8	16	10	...	...	62·5
17.4.17	2.5.17	12	6	2	...	...	33·3
4.5.17	26.5.17	19	35	8	5	13	76·0
8.6.17	27.6.17	16	24	14	...	...	58·3
13.6.17	27.6.17	11	8	6	...	...	75·0
19.6.17	27.6.17	5	108	45	...	...	41·7
2.1.18	18.1.18	13	25	14	4	1	76·0

Thus in this experiment of two hundred and twenty-eight eggs which failed to hatch during continuous immersion in water for periods varying from five to nineteen days longer than is generally required by non-resistant eggs, one hundred and twenty-eight were induced to hatch after periods of cooling ranging from two to forty-eight hours. Of these one hundred and twenty-eight eggs, one hundred and five hatched within two hours of being placed in the ice chest, nine within twenty-four hours, and fourteen within forty-eight hours.

The effect of lysol on resistant eggs

In certain experiments carried out at this Institute, it was found necessary to sterilize the eggs of *Stegomyia*, lysol being selected as a suitable agent. It was noted that after a short period of immersion in the disinfectant, resistant eggs hatched out soon after being submerged in water. This finding suggested the following experiment (VIII).

The eggs used were from the stock-breeding cages, and proved to be of average fertility. They remained in or on water from the time of laying until immersed for thirty seconds in lysol (of the strength retailed by the manufacturers), the overdue period being reckoned from the third day after laying to the date of immersion in the disinfectant. After treatment in lysol, the eggs were drained on filter paper and then immersed in water, the controls remaining in water throughout. The results of this treatment are shown in Experiment VIII.

EXPERIMENT VIII

Expt.	No. of eggs treated	No. of control eggs	Date of treatment	No. of days over-due in hatching	No. of eggs hatched inside 2 hours.		No. of eggs hatched in 24 hours		Per ha afte
					Treated	Control	Treated	Control	
1	13	3	20.5.17	11	7	0	5	0	9
2	2	3	28.5.17	7	2	0	...	0	1
3	2	3	28.5.17	7	2	0	...	0	1
4	5	3	28.5.17	7	2	0	2	0	8
5	3	...	28.5.17	6	2	...	1	...	1
6	3	...	29.5.17	8	2	...	1	...	1
7	7	1	4.6.17	7	7	0	...	1	1
8	5	7	5.6.17	8	3	0	2	0	1
9	2	5	7.6.17	10	2	0	...	1	1
10	4	...	8.6.17	11	2	...	2	...	1
11	6	6	11.6.17	14	3	0	...	0	[illegible]
12	3	3	14.6.17	17	3	0	...	0	1
13	3	...	15.6.17	18	1	...	...	...	[illegible]

In this experiment (VIII), fifty-eight resistant eggs were treated with lysol, whilst thirty-four were used as controls. Of the former, thirty-eight hatched within one to two hours following their re-immersion in water after the lysol treatment, and thirteen others followed during the succeeding twenty-four hours. In all 87·9 per cent. hatched. Of the thirty-four controls, none hatched during the first one to two hours following the commencement of the experiment, and two only during the first twenty-four hours.

The effect of 2·5 per cent. soap solution on resistant eggs

Bacot, experimenting with larvicides, found that petroleum soft soap emulsion 1-8000, acted as a stimulus to the hatching of resistant eggs in a similar manner to lysol. The present observations show that soap solutions without petroleum also have a similar action.

In my experiment (Experiment IX) eggs were taken from the stock-breeding cages and kept continuously in or floating upon water up to the time of their immersion in the soap solution. The overdue period was reckoned, as in the former experiments, from three days after laying to the time of immersion in soap solution. The eggs were placed in the solution without preliminary drying and, after about five minutes' immersion, were returned to tap water.

EXPERIMENT IX

o. of eggs treated	No. of control eggs	Date of treatment	No. of days overdue in hatching	No. of eggs hatched inside 2 hours		No. of eggs hatched in 24 hours		Percentage
				Treated	Control	Treated	Control	
4	3	20.6.17	13	3	0	1	0	100·0
4	3	20.6.17	13	1	0	0	0	25·0
5	2	20.6.17	15	1	0	0	0	20·0
6	...	22.6.17	17	5	...	0	...	83·3
4	3	22.6.17	20	3	0	0	0	75·0
6	3	24.6.17	20	4	0	0	0	66·7
5	5	25.6.17	23	4	0	0	1	80·0
4	5	25.6.17	23	4	0	...	0	100·0
5	5	25.6.17	23	3	0	0	0	60·0
10	...	27.6.17	25-27	7	...	0	...	70·0

Thus fifty-three resistant eggs were treated with soap solution and twenty-nine used as controls; thirty-five of the former hatched within one to two hours of their re-immersion in tap water following five minutes' immersion in the solution, and one hatched during the twenty-four hours following the treatment. In all 69·2 per cent. hatched within twenty-four hours. Of the seventeen which failed to hatch, two (one in No. 2 and one in No. 3) were found to be infertile and fifteen to contain either living or dead larvae. Only one of the control eggs hatched.

The influence of submergence of eggs upon hatching

EXPERIMENT X

In order to ascertain the difference, if any, in the hatching period of submerged eggs and those floating on the surface film, forty-five eggs laid during the night of 28th April were divided into two batches on the following morning, 'A' containing twenty-two eggs and 'B' twenty-three eggs. The former ('A') were submerged on filter paper in a dish containing 300 c.c. of tap water, whilst the latter ('B') were allowed to float on the surface film of a similarly prepared dish.

Batch 'A' (submerged) hatched as follows: eighteen on the third day and one on the twenty-third day. The three remaining eggs were taken from the water, dried and dissected on the twenty-eighth day, when they were found to be collapsed. In batch 'B' (floating), twenty-one eggs hatched on the third day and one on each of the fourth and fifth day.

From this one experiment it would appear that the position of the eggs in the containers, i.e., whether floating or submerged, has little influence upon the hatching, since in 'A' 81·8 per cent. of the total eggs, i.e., 94·7 per cent. of the total *fertile* eggs in the batch, hatched on the third day, and in 'B' 91·3 per cent. of the total. This view is supported by observations during the routine work of breeding *Stegomyia*.

The effect of sea water upon the hatching of eggs

On dry storage eggs

EXPERIMENT XI

Three hundred eggs, after having been dry stored for a period of three weeks, were divided into two equal batches, 'A' being placed in 300 c.c. of sea water and 'B' in 300 c.c. of tap water. The effects of this immersion are shown in Table 3.

TABLE 3.

"A" In sea water		"B" In tap water	
Total number of eggs hatched at the end of :—		Total number of eggs hatched at the end of :—	
15 minutes ...	20	15 minutes	nil
30 minutes ...	40	30 minutes	30
60 minutes ...	96	90 minutes	34
27 hours	110	2 hours ...	70
		5 hours ...	85
		27 hours ...	125
Percentage hatched	77·3	Percentage hatched	83·3

On freshly laid eggs

EXPERIMENT XII

Two hundred eggs which were laid during the previous night were transferred in the morning from the dish of fresh water to a jar containing sea water. After fifteen days' immersion in sea water they were divided into ten batches of twenty eggs each, and placed in bottles, (1) containing tap water, (2) containing 10 per cent. sea water, (3) containing 20 per cent. sea water, and so on up to 90 per cent. sea water. The subsequent history of these eggs is shown in Table 4.

TABLE 4.

No.	Contents of bottle	No. of eggs hatched	Length of larval life or subsequent stage of development reached
1	Tap water	17	16 adults reared
2	Tap water plus 10% sea water ...	5	5 adults reared
3	,, ,, 20% ,, ...	4	4 adults reared
4	,, ,, 30% ,, ...	5	4 adults and 1 pupa reared
5	,, ,, 40% ,, ...	2	1 adult reared, 1 larva lived three days
6	,, ,, 50% ,, ...	5	5 larvae lived three days
7	,, ,, 60% ,, ...	1	lived one day
8	,, ,, 70% ,, ...	1	lived under 16 hours
9	,, ,, 80% ,, ...	1	lived under 16 hours
10	,, ,, 90% ,, ...	0	—

The effects on hatching of submergence in small or large quantities of water

Bacot's experiments to elucidate the above question failed to bring forth any very conclusive evidence, but it appeared from them that slightly increased mortality and delayed hatching followed as a result of submergence in a small quantity of water. Nor do the present experiments afford convincing evidence, but such as has been adduced is in support of Bacot's finding regarding the increased mortality amongst eggs submerged in small quantities of water.

In the first of these experiments, thirty eggs laid during the night of 25th May were divided into two batches and submerged on filter paper, 'A' in 300 c.c. and 'B' in 1,300 c.c. of tap water.

In the second, sixty eggs laid on 30th May were similarly treated. The results are readily seen in Tables 5 and 6.

TABLE 5.

Batch	Day																	Mortali
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	28	
'A'	6	1	...	...	...	...	...	2	4	...	...	...	...	...	...	...	...	13·3%
'B'	8	2	1	...	...	2	...	...	1	1	...	...	...	...	...	...	...	nil

The two remaining eggs in 'A' failed to hatch by the twenty-eighth day.

TABLE 6.

Batch	Day																			
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
'A'	...	25	...	...	2	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
'B'	...	20	...	3	4	...	...	2	...	1	...	...	...	...	...	...	...	...	...	...

The two remaining eggs in 'A' which failed to hatch by the sixtieth day were dried and found to be collapsed (dead).

The influence of temperature and environment on the hatching of eggs and the development of the resulting larvae

In Experiment XIII, ninety eggs recently laid were divided into three batches each containing thirty eggs. Each batch was placed in 200 c.c. of tap water with 0·5 gram of polished rice.

'A' was kept in the laboratory at room temperature, i.e., about 78° F.

'B' was kept in an incubator at a temperature of about 95° F.

'C' was kept in an ice chest at a temperature varying from 56° to 59° F.

For details of the results see Experiment XIII.

Experiment XIII

h	Eggs	Day												
		3	4	5	6	7	8	9	10	11	12	13	14	15
	30	1L.	5L.	3L.	1L.	2L.	12L.	...	...	1P.	2P.	1P.	...	5P. 3M.
	30	1L.	...	...	...	2L.	9L.	...	2L.	...	...	3L.	...	1P. (*a*)
	30	...	...	...	...	...	2L.	5L.	1L.	...	1L.	...	4L.	2L.

Experiment XIII (*continued*)

h	Eggs	Day												
		16	17	18	19	20	22	23	24	25	26	27	38	103
	30	1P. 2M.	3P. 1M.	3M.	2M.	2M.	2P.	2P.	6P.	1P. 3M.	2M.	6M.	...	...
	30	...	...	...	...	...	...	...	...	L. (*b*)	...	...	...	...
	30	...	...	...	...	...	...	...	...	...	...	...	1P. (*c*)	L. (*d*)

Note :—'L.' = larva
'P.' = pupa
'M.' = adult

(*a*) pupated and died on 15th day
(*b*) the last larva died on 25th day
(*c*) this pupa died two days later
(*d*) the last larva died on 103rd day

Thus of thirty eggs kept under the above conditions in the laboratory, twenty-four, or 80 per cent., produced larvae, all of which pupated and subsequently produced adults. Of the thirty kept in the incubator, seventeen, or 56·6 per cent., produced larvae, only one of which pupated; this one died on the same day. The last surviving larva died on the twenty-fifth day. Of the thirty eggs placed in the ice chest, fifteen, or 50 per cent., hatched, of which number only one pupated. This pupa died two days later. The last surviving larva died on the hundred and third day.

In Experiment XIV, one hundred and ten eggs were divided into three batches, 'A' and 'B' containing thirty-eight eggs and 'C' thirty-four eggs. The methods of storing and the temperature were the same as the corresponding batches in Experiment XIII. The results are shown in the following statement:—

EXPERIMENT XIV

Batch	Eggs	Day								
		5	6	7	8	9	10	11	12	13
'A'	38	...	...	4L.	8L.	2L.	1L.	...	9L. 1P.	...
'B'	38	4L.	...	...	6L.	...	...	8L.	...	1P. (*a*)
'C'	34	...	...	...	...	1L.	...	...	...	1L.

EXPERIMENT XIV (*continued*).

Batch	Eggs	Day								
		14	15	16	17	18	19	20	21	47
'A'	38	... 3P.	2P. 1M.	1P.	2P. 4M.	... 2M.	2P.	... 1M.	... 2M.	...
'B'	38	...	...	...	...	...	...	...	L. (*b*)	...
'C'	34	...	...	12L.	1L.	...	...	...	...	L. (*c*)

(*a*) This pupa lived only two days.

(*b*) The last surviving larva died on 21st day.

(*c*) The last surviving larva died on 47th day.

Thus of thirty-eight eggs kept in the laboratory twenty-four (63·1 per cent.) hatched. Of these twenty-four larvae eleven (45·8 per cent.) pupated, and ten of the eleven (90·9 per cent.) produced adults. The percentage of adults reared from the thirty-eight eggs was therefore 26·3. Of thirty-eight eggs placed in the incubator eighteen (47·3 per cent.) hatched, one of which reached the pupal stage but survived only two days. Fifteen of the thirty-four eggs placed in the ice chest produced larvae, none of which pupated, although one lived to the forty-seventh day. The low percentage of hatching in 'A,' Experiment XIV, as compared with 'A,' Experiment XIII, is not accounted for.

The influence of sunlight, diffused light, and darkness on the hatching of eggs and development of subsequent stages

EXPERIMENT XV

In this experiment, one hundred and five eggs were divided into three batches, which were treated in the following manner:—

Batch 'A,' containing forty-five eggs placed in 1,300 c.c. tap water with a small quantity of fowl faeces, was stored on the verandah, where it was exposed to direct sunlight during the day and to the lower temperature of night.

Batch 'B,' containing thirty eggs placed in 1,300 c.c. tap water with a small quantity of fowl faeces, was stored in a photographic dark room.

Batch 'C,' containing thirty eggs, was treated similarly to 'A' and 'B,' excepting that it was stored in the laboratory.

The results are shown in the tabulated statement XV.

EXPERIMENT XV

Batch	Eggs	Day									
		3	4	6	7	8	9	10	11	12	13
A' exposed to irect sunlight	45	...	35L.	...	...	...	...	...	...	12P.	5P. 1M.
B' darkroom	30	...	24L.	...	...	5P.	5P.	3P.	1P. 8M.	... 1M.	... 4M.
C' exposed to iffused sunlight	30	16L.	...	2L.	2L.	8P.	...	8P.	... 13M.	2P. 3M.	2P.

Experiment XV (*continued*).

Batch	Eggs	Day								
		14	15	16	17	18	19	21	29	32
'A' exposed to direct sunlight	45	2P. 5M.	6P. 2M.	… 15M.	1P. 1M.	… 1M.	…	… 1M.	1P.	… 1M.
'B' darkroom	30	… 1M.	…	…	…	1P.	… 1M.	…	…	…
'C' exposed to diffused sunlight	30	… 3M.	… 1M.	…	…	…	…	…	…	…

Thus in 'A,' thirty-five (77·7 per cent.) larvae hatched from forty-five eggs, and twenty-seven (77·1 per cent.) of these larvae ultimately produced adults.

In 'B,' twenty-four (80 per cent.) larvae hatched from thirty eggs, of which number fifteen (62·5 per cent.) produced adults.

In 'C,' twenty (66·6 per cent.) larvae hatched from thirty eggs, all of which larvae produced adults.

It will be seen that the lowest percentage of hatching occurred i the laboratory (Batch 'C'), where 100 per cent. of those which di hatch ultimately produced adults. It should be noted, however that no observations were made on the unhatched eggs after th thirty-second day; it is quite possible, therefore, that all, or a larg proportion of them, may have been naturally resistant.

2. LARVAE

The effect of light or absence of light on the development of larvae

Experiment XVI

Twenty larvae which hatched between 9.45 a.m. and 11.45 a.m on 24th March were divided into two equal batches, and each batc placed in a bottle containing 5 or 6 grains of rice and 10 ozs. ta water. One bottle ('A') was stored in the photographic darkroo the other ('B') on the laboratory windowsill. All the larva excepting two of those in 'A,' pupated between 5 p.m. 27th March and 8.45 on 28th March. On the next day (29th) o of the pupae in 'A' died. On the 30th (about 10 a.m.) the remaining seven pupae in 'A' and the full number (ten) in 'B' produced adults.

In this experiment it would appear that the development of the larvae under artificial conditions and at room temperature is not influenced by the presence or absence of light.

Experiment XVII.

'A.'	On verandah exposed to the sun	Food given, 0·3 per cent. in 1300 c.c. of water.
'B.'	In dark-room	
'C.'	In workroom	
'D.'	In ice chest and room temperature alternately	

Day.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
...	...	...	...	...	...	...	...	2P.	5P. 1F.	2P. 2M. 3F.	6P. 2M. 2F.	1P. 5F.	2P. 1M.	1P. 1M.	1P. 2M
...	...	...	5P.	...	5P.	3P.	1P. 6F. 3M.	4P. 2F.	1P. 3F. 1M.	... 4M.	...	...	...	1P.	...
...	...	...	...	...	8P.	...	8P.	... 10F. 3M.	2P. 2F. 1M.	2P.	... 3F.	... 1F.	...	...	...
..	...	...	...	...	...	...	...	...	1P.	1P.	2P.	4P.	2P. 1M.	2P. 3F.	... 2F. 4M.

Experiment XVII (*continued*).

Day.															
17	18	19	21	22	23	24	25	26	27	28	29	30	31	33	36
...	... 1M.	...	...	...	...	...	...	1P.	...	...	... 1M.	...	...	...	...
... 1M.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10P. 2F.	5P. 2F. 1M.	... 1F. 1M.	... 1F. 1M.	... 1M.	...	... 3F. 2M.	...	... 1F. 1M.	...	1P.	...	...	1P.	?	?

.—'M' = Male. 'F' = Female. 'P' = Pupa.

Thus in 'A' 21 larvae completed their life cycle—84 per cent. reared in 28 days. In 'B' 20 larvae completed their life cycle—83·3 per cent. reared in 16 days. In 'C' all larvae completed their life cycle—100 per cent. reared in 12 days. In 'D' 31 larvae completed their life cycle—96 per cent. reared in 36 days.

The effect of temperature and darkness on the development of recently hatched larvae

The larvae in these two experiments (Experiments XVIII and XIX) hatched overnight. In Experiment XVIII, thirty larvae were divided into two equal batches, 'A' and 'B,' each of which was placed in 100 c.c. tap water containing 0·25 grams of fowl faeces. 'A' was kept in an incubator at 98·6° F. and 'B' in a second incubator which was not artificially heated, the temperature being about 78·8° F. The results are shown hereunder:—

EXPERIMENT XVIII

Batch	Larvae	Day.										
		1	5	7	8	9	11	12	13	14	16	18
'A'	15	...	1P. (*a*)	...	L. (*b*)	...	...	...	...	...	...	...
'B'	15	...	...	...	6P.	6P. 1M.	... 4M.	2P. 4M.	... 1M.	... 3M.	1P.	... 1M.

NOTE.—'L' = Larva. 'P' = Pupa. 'M' = Adult.

(*a*) The first larva pupated on the fifth day and died on the seventh.

(*b*) The remaining larvae were all dead on the eighth day.

Thus in 'A' (temperature 98·6° F.) only one larva pupated, and this lived only two days. The remaining larvae died by the eighth day.

In 'B' (temperature 78·8° F.) only 6·7 per cent. of the larvae failed to produce adults.

EXPERIMENT XIX

Batch	Larvae	Days					
		10	11	12	13	14	15
'A'	10	L.(a)	...	...	...	...	...
'B'	10	3P.	5P.	1P.	1P. 4M.	... 2M.	... 1M.

(a) All the larvae were dead on the tenth day.

Thus in 'A' (temperature 98·6° F.) none of the larvae survived, but in 'B' (temperature 78·8° F.) only 10 per cent. of the larvae failed to produce adults.

From these experiments it would appear that excessive heat and not darkness was responsible for the mortality. In both experiments (XVIII 'B' and XIX 'B') the larval period was longer than usual, i.e., from ten to thirteen days in the latter.

Subsequent records of experiments will show that the lengthened larval period was probably due to unsuitable feeding, since it has been shown in Experiment XVI that the absence of light does not retard larval development.

Quantity and nature of food, and its influence on larval development

In this experiment (XX) forty newly hatched larvae were placed in each of five vessels containing 300 c.c. tap water and 0·1 per cent. of food as follows:—

P.R.	0·3 grm. polished rice.
M.L.	0·3 grm. dry mango leaf.
F.F.	0·3 grm. dry fowl faeces.
B.	0·3 c.c. broth, previously exposed to the air for two days, with luxuriant growth of bacteria.
F.M.	0·3 grm. fresh fly maggot (dead).

The average laboratory temperature during the experiment was about 71° F. The results are shown in the corresponding statement (XX).

EXPERIMENT XX

Batch	Larvae	Day								
		8	9	10	11	12	13	14	15	16
P.R.	40	1P.	11P.	4P.	8P. 3M.	3P.	1P.	...	3P. 6M.	... 1M.
M.L.	40	...	...	...	...	...	...	...	...	1P.
F.F.	40	1P.	3P.	4P.	1P.	1P. 4M.	3P. 5M.	... 2M.	1M.	1P.
B.	40*	...	...	...	...	...	...	...	...	...
F.M.	40	1P.	...	... 1M.	1P.	...	2P.	... 1M.	...	... 2M.

EXPERIMENT XX (*Continued*).

Batch	Larvae	Day							
		17	18	19	20	21	22	23	24
P.R.	40	... 1M.	... 2M.	...	2P.	...	...	... 1M.	...
M.L.	40	...	...	... 1M.	...	...	...	...	...
F.F.	40	1P.	... 1M.	1P.	...	1P. 1M.	... 2M.	1P.	... 1M.
B.	40*	...	...	...	...	...	...	...	...
F.M.	40	...	...	...	...	...	...	...	...

* All died in larval stage.

The mortality totals in the above 0·1 per cent. foods are therefore seen to be:—P.R. 65·0 per cent., M.L. 97·5 per cent., F.F. 57·5 per cent., B. 100 per cent., and F.M. 90 per cent.

EXPERIMENT XXI

The number of larvae used in this experiment varied between ten and thirteen to each batch. All were recently hatched. Each batch was liberated in a vessel containing 400 c.c. tap water and 0·25 per cent. of food, as follows:—

M.L.	1·0 gram	dry mango leaf.
D.C.	1·0 ,,	dried cockroach.
H.D.	1·0 ,,	dried horse faeces.
P.R.	1·0 ,,	polished rice.
G.S.	2·0 c.c.	goat serum.

The results are shown in the corresponding statement (XXI).

EXPERIMENT XXI

Batch	Larvae	Day								
		5	6	7	8	9	10	11	12	13
M.L.	13	1P.	1P.	1P.	... 3M.	2P.	1P. 2M.	1P. 1M.	1P. 1M.	1M.
D.C.	10	...	4P.	2P.	... 4M.	2P. 2M.	... 2M.	...	...	...
H.D.	10	...	...	...	...	1P.	...	2P.	... 3M.	1P.
P.R.	13	11P.	... 11M.	...	...	...	...	...	...	...
G.S.	13	...	1P.	2P.	1P. 2M.	3P. 2M.	...	... 3M.	...	...

EXPERIMENT XXI (*continued*).

Batch	Larvae	Day							
		14	15	16	17	18	19	20	21
M.L.	13	...	...	1P.	...	1P. 1M.	1P. 1M.	...	... 1M.
D.C.	10	...	1P.	...	... 1M.	...	...	...	...
H.D.	10	1P.	... 1M.	...	... 1M.	...	...	...	...
P.R.	13	...	...	...	...	1P.	...	... 1M.	...
G.S.	13	2P.	1P.	1P.	... 3M.	... 1M.	... 1M.	...	...

Thus the mortality totals in 0·25 per cent. of the foods shown above are as follows:—M.L. 15·4 per cent., D.C. 10 per cent., H.D. 50 per cent., P.R. 7·7 per cent., and G.S. 7·7 per cent.

EXPERIMENT XXII

From nine to seventeen recently hatched larvae were liberated in each of nine vessels containing 400 c.c. tap water and 0·3 per cent. of food, as follows:—

M.L.	1·2 gram.	dry mango leaf.
D.C.	,,	dry cockroach.
H.D.	,,	dry horse faeces.
P.R.	,,	polished rice.
P.	,,	peptone.
P.S.	0·15 per cent.	peptone solution, tweny-four hours old, filtered.
B.C.	1 ,,	agar slant, B. coli.
B.C.2	½ ,,	,, ,, ,,
H.U.	4 c.c.	human urine.

The results are shown in the corresponding statement (XXII).

EXPERIMENT XXII.

Batch	Larvae	Day									
		5	6	7	8	9	10	11	12	14	18
M.L.	17	3P.	6P.	... 4M.	5P. 4M.	...	1P. 6M.	...	1P.	... 2M.	...
D.C.	17	2P.	5P.	6P. 1M.	... 4M.	3P. 5M.	...	... 4M.	...	...	...
H.D.	9	2P.	2P.	... 2M.	...	...	... 2M.	...	...	...	...
P.R.	9	5P.	2P.	...	... 7M.	...	...	...	...	...	...
P.	15	...	1P.	...	...	...	...	...	...	...	...
P.S.	9	5P.	3P. 1M.	... 3M.	1P. 4M.	...	... 1M.	...	...	...	...
B.C.	11	7P.	2P. 1M.	... 5M.	... 2M.	...	...	... 1M.	...	...	...
B.C.2	10	5P.	1P.	... 5M.	...	...	... 1M.	1P.	...	1P. 1M.	... 1M.
H.U.	9	4P.	... 1M.	... 2M.	1P. 1M.	1P. 1M.	... 1M.	...	...	1P.	... 1M.

Thus the mortality totals in 0·3 per cent. of the foods shown are as follows:—M.L. 5·9 per cent., D.C. 5·9 per cent., H.D. 55·5 per cent., P.R. 22·2 per cent., P. 93 per cent., P.S. nil, B.C. 18·2 per cent., B.C.2 20 per cent., and H.U. 22·2 per cent.

The results of these three experiments are tabulated in Table 7.

TABLE 7.

Batch	Nature of food	Percentage of food to water	Percentage of mortality
P.R.	Polished rice	0·1 0·25 0·3	65·0 7·7 22·2
M.L.	Mango leaf	0·1 0·25 0·3	97·5 15·4 5·9
F.F.	Fowl faeces	0·1 0·25 0·3	57·5 ... ...
B.	Broth	0·1 0·25 0·3	100·0 ... ...
F.M.	Fly maggot	0·1 0·25 0·3	90·0 ... ...
D.C.	Cockroach	0·1 0·25 0·3	... 10·0 5·9
H.D.	Horse faeces	0·1 0·25 0·3	... 50·0 55·5
G.S.	Goat serum	0·1 0·25 0·3	... 7·7 ...
P.	Peptone	0·1 0·25 0·3	... ... 93·3
P.S.	Peptone Solution	0·15	nil
B.C.	1 agar slant *B. coli*	...	18·2
B.C.2	½ agar slant *B. coli*	...	20·0
H.U.	Human urine	1·0	22·2

EXPERIMENT XXIII

'A.' 200 c.c. of tap water containing 0·5 per cent. rice starch.
'B.' ,, ,, ,, with the addition of 5 per cent. sugar.
'C.' ,, ,, ,, with the addition of half the white of an egg.
'D.' ,, ,, ,, containing piece of banana (removed after the third day).

The results are shown in the corresponding tabulated statement (XXIII).

Batch	Larvae	Day								
		7	8	9	10	11	12	13	14	15
'A'	22	...	...	...	...	...	...	3P.	...	...
'B'	20	L. (a)	...	...	...	...	...	...	...	...
'C'	20	...	...	9P.	1P.	... 1M.	... 6M.	3P. 2M.	...	1P. 3M.
'D'	30	1P.	8P.	5P.	6P.	... 1M.	4P. 4M.	... 2M.	1P. 9M.	2P. 5M.

EXPERIMENT XXIII (*continued*).

Batch	Larvae	Day								
		16	17	18	19	21	22	23	24	25
'A'	22	... 3M.	...	11P.	...	1P.	1P.	... 11M.	2P.	... 4M.
'B'	20	...	...	...	...	...	...	L. (*b*)	...	...
'C'	20	2P. 1M.	...	(*c*)	(*d*)	...	...	...	...	1P.
'D'	30	...	... 6M.	...	(*e*)	...	...	...	...	...

(*a*) Some of the larvae now in second skin.
(*b*) Larvae in second and third skin.
(*c*) Two pupae and one larva died.
(*d*) One pupa died.
(*e*) The remaining larvae died.

Mortality 'A'	...	...	...	18·2	per cent.
,, 'B'	...	...	...	100	,,
,, 'C'	...	...	...	35	,,
,, 'D'	...	...	...	10	,,

The effects of an increase of temperature on larvae and pupae of Stegomyia

A number of recently hatched larvae were placed in water in beakers heated over a water bath. When the temperature reached 114·8° F., 75 per cent. of the larvae were found to be dead, and the remainder failed to develop when the water was gradually reduced to room temperature.

Further experiments were then carried out with older larvae, i.e., larvae in their third skin, and with pupae. The procedure was the same as in the first experiment. The results of these experiments are seen in the tabulated statement (XXIV).

Experiment XXIV

	Temperature	Number used		Number subsequently reared	Number killed by heating	Mortality
		Larvae	Pupae			
1	90° F.	10	3	all	nil	nil
2	95° F.	10	3	all	nil	nil
3	100° F.	10	3	all	nil	nil
4	105° F.	10	3	10	3 larvae	23%
5	110° F.	10	3	4	2 pupae 7 larvae	69·2%
6	115° F.	10	3	nil	all	100%

From the foregoing statement it will be seen that the approximate maximum temperature that the larvae and pupae are capable of withstanding without great mortality is about 105° F.; beyond this temperature there is a very great increase in the mortaliy. Bacot showed that a temperature of 112° F. caused a mortality of 50 per cent., and that higher temperatures caused the death of all larvae and pupae experimented with.

The survival of larvae and pupae out of water

Experiment XXV

(1) On filter paper kept slightly moist

Thirty-four larvae and five pupae were placed on wet filter paper and kept moist by adding a few drops of water each day. Two adult mosquitoes emerged on the following day, two others on the second day and the remaining one on the fourth day. The larvae were left on the paper until the fifteenth day, when only two of them remained alive. These two were then transferred to a bottle of water, but failed to reach the pupal stage.

(2) On wet filter paper and allowed to dry in muslin covered dish

Larvae and pupae were placed on wet filter paper in a muslin covered dish and allowed to dry gradually. Two larvae and one pupa were removed to water at the end of thirty-two hours, when the paper was nearly dry, and all of them eventually developed into adults.

Of two larvae and one pupa removed at the end of forty-seven and a half hours, only the latter was alive, but this died soon after in a dish of water. Another pupa, however, was alive after fifty and a half hours on the paper, but was dead at seventy-two hours. None of the larvae appeared to have survived beyond thirty-two hours.

(3) On wet filter paper and allowed to dry in a glass covered dish

Thirty-one larvae were placed on wet filter paper and put on a glass covered petri dish. After sixty-five hours in this dish seven larvae were removed to water, where one of the seven eventually matured. The remaining twenty-four larvae were transferred to water after having been on the paper for eighty-nine hours. Of these five were alive, but one died during the following twenty-four hours. The remaining four lived for nine days, after which no further record of them was kept.

3. ADULTS

Length of life of adult mosquitoes in captivity when unfed and fed on various foods

The mosquitoes used in this experiment (XXVI) were recently emerged laboratory-bred insects, all of which (except A.) were given an opportunity of feeding daily during the course of the experiment. The various batches were kept in similar cages and treated similarly to each other, excepting with regard to the food given. The average daily temperature was between 71° F. and 80° F.

A. Not fed.
B. Fed on syrup.
C. Milk and sugar.
D. Banana.
E. Blood once (females); banana afterwards.
F. Blood for sixty-one days, then bananas (females); banana only for males.

The results are shown in the following tabulated statement:—

Experiment XXVI

umber adults used	Day														
	2	4	7	12	15	19	26	30	35	47	51	58	61	68	93
25F. 12M.	9F. 8M.	15F. 4M.	1F.	...	...	...	...	...	...	...	...	...	...	...	...
7F. 4M.	...	2M.	2F.	...	2F.	2F. 1M.	1F.	1M.	...	...	...	...	...	...	...
7F. 2M.	...	...	1F.	1F. 2M.	2F.	2F.	...	...	...	...	...	...	...	...	...
5F. 5M.	...	...	...	...	...	1F. 1M.	1M.	1F. 1M.	1F. 1M.	1F. 1M.	...	...	...	1F.	...
3F. 1M.	...	...	...	...	...	...	1F. (*e*)	1M.	1F.	...	...	...	1F.	...	...
5F. 5M.	...	...	...	5F.	...	5F. 1M.	...	1F. 2M.	...	1F. 1M.	1F.	1F.	1M.	...	1F.

(*e*) = Escaped from cage. F. = Females. M. = Males.

Retention of eggs by gravid females

Oviposition on dry surfaces

It is a generally accepted belief that either water or a damp surface is essential to oviposition, and that if such is not available the gravid female will retain her eggs for a long period—until her death or until favourable conditions are made available. My experience in the routine of breeding *Stegomyia*, as well as the results of a number of experiments undertaken especially to confirm former observations, convince me that this belief is well founded.

Oviposition on oily surface

That similar results follow the provision in the breeding cages of only water having a surface film of oil is shown by the following experiments:—

EXPERIMENT XXVII

On the morning of 11th September, two gravid females and four males were placed in a breeding cage containing a dish of tap water covered with a thin film of kerosene. For several days previously the females had fed on human blood and the males on banana, which foods were offered daily during the progress of the experiment. The following observations were subsequently recorded:—

11th September (afternoon), one female fed. 13th, one female fed. 14th, one female fed; three males drowned. 17th, a female drowned. 19th, the remaining male drowned, three others liberated in cage. The remaining female fed on 29th September and on 4th October. No eggs laid up to this date. A dish of tap water without oil on surface was put into the cage, and the first dish (with oil) removed. 5th October, forty-six eggs laid over-night, the first oviposition during her twenty-four days of captivity. Female fed in afternoon. 15th October, seventy-nine eggs laid over-night. Dish of fresh water removed and replaced by one containing water with oily film. 16th October, female fed. 22nd October, female fed, and at intervals of about three days until her death. One male drowned. 24th October, one male drowned. 25th October, one male drowned. 8th November, female drowned.

Egg laying by unfertilised females

We have noticed on several occasions that certain batches of eggs produced females only, and that when segregated and fed on human blood these unfertilised insects were capable of laying eggs.

In this connection the following experiment is of interest as showing the increase which takes place in egg production after fertilisation.

The mosquitoes used in this experiment, seven in number, were reared from a batch of eggs which produced females only, and as soon as possible after hatching they were segregated in such manner as to preclude the possibility of fertilization. Opportunities for feeding on human blood were given frequently from the date of emergence, i.e., 7th September. After thirty days of captivity in this manner, two males were liberated in the cage with the five surviving females for seventeen hours, with the results shown in Experiment XXVIII.

EXPERIMENT XXVIII

Dates on which eggs were laid	Number of eggs laid	Approx. number proved fertile	Fertility	Deaths to date	Feeds given to date	Remarks
22.9.17	5	...	...	2	14	
24.9.17	6	...	...	...	16	
1.10.17	85	...	...	...	19	Total number of eggs laid by unfertilised females: 105
8.10.17	9	...	...	...	23	Total number of feeds given: 23
4 p.m. 8.10.17 to 9 a.m. 9.10.17	(17 hours) 2 males liberated in cage with 5 surviving females.					
10.10.17	60	30	+	...	28	
12-13.10.17	78	78	+	...	...	
15.10.17	12	3	+	...	31	
17.10.17	31	31	+	...	33	
18.10.17	60	60	+	...	35	
22.10.17	140	140	+	...	39	
25.10.17	52	38	+	1	41	
29.10.17	120	100	+	...	...	
2.11.17	72	60	+	1	...	
7.11.17	140	100	+	1	44	Total number of eggs laid by fertilised females: 765
8.11.17	...	...	...	2	...	Total number of feeds given to fertilised females: 21

From the foregoing it will be seen that seven unfertilised females did not lay eggs during the first fifteen days, and that during this period two died. During the following fifteen days the remaining five females laid one hundred and five infertile eggs and were then mated with two males. During the thirty days following the introduction of the males seven hundred and sixty-five eggs were laid, of which number approximately six hundred and forty proved fertile.

Experiments to ascertain whether Stegomyia fasciata *would lay eggs when fed on food other than blood*

From time to time various batches of mosquitoes were given food other than blood for periods ranging from twenty-five days to one hundred and forty days. The following foods were experimented with :—

Concentrated sugar solutions	4	experiments.
Concentrated peptone and sugar solution	3	,,
Concentrated sugar and haemoglobin solution	3	,,
Milk and sugar	2	,,
Banana	1	,,
Peptone solution	2	,,
Syrup	1	,,
Honey	1	,,
Dates	1	,,
Apple	1	,,

In each of the three experiments in which peptone and sugar were given as food a number of eggs were laid, about 60 per cent. of which were fertile. In all other experiments there was no egg production.

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Effect of Exercise and Humid Heat upon Pulse Rate, Blood Pressure, Body Temperature, and Blood Concentration.

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(Communicated by Prof. N. Langley, F.R.S. Received August 14, 1919.)

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The effect of exercise on the human body has been made the subject of much study at different times. Researches have been carried out under atmospheric conditions such as prevail in different parts of Northern Europe, and they have been extended in a few instances to the effects of high temperature and humidity upon the human body. In the latter observations the conditions such as high temperature and varying humidity were produced by artificial means only, and general deductions as to the influence of an actual tropical climate upon the human organism cannot be safely drawn from them. In these experiments the subjects were living in a temperate climate, were exposed to heat and humidity for a short time only, and left the hot chamber at the end of the experiment for an atmosphere of coolness and comfort; in the tropics, on the other hand, the inhabitants are continuously exposed to heat and humidity without respite. Conclusions of real value can thus be drawn only from observations actually carried out in a hot climate, and systematic work in this direction is still lacking.

Although observations have been made in the tropics on body temperature, blood pressure, pulse and respiration rate, and metabolism, yet their object has only been to obtain normal standards for the tropics for comparison with those of Europe.

The following experiments were carried out in Townsville during the hottest months of the year (January to March), during which time the wet-bulb temperature stands between 75° and 80° F., occasionally even above, and the dry-bulb temperature between 80° and 90° F.; the degree of saturation of the atmosphere is very high, and the climate "trying." The climatic conditions—rainfall and temperature—in Townsville correspond, according to Griffith Taylor (1918), to those in Calcutta, with the exception that the humidity is slightly lower.

Methods.

The observations recorded were made on the staff of the Institute subjects I to VI and VIII), and extended over two wet seasons. During he early part of the second year one of the authors (W. A. O., subject VII), during a visit to Townsville, joined in the research. The experiments were of three kinds. In a first series the effect of vigorous exercise of short duration was studied. The effort consisted in running up and down a staircase, about 15 feet high, as fast as possible; with few exceptions the feat was repeated 10 times, and the time taken varied from 118 to 150 seconds.

The second series comprised a number of experiments, in which the exercise consisted in walking for a varying period at a moderate pace (three to four miles an hour) during the hottest hours of the day. In one walking experiment on a very hot day (dry bulb 86·4°, wet bulb 81·0°), the observations were taken on three subjects (I, II, and III) at quarter-hourly intervals for two hours (the duration of the walk), and this experiment is treated separately, the observations being plotted in the accompanying chart.

In a third series of observations the effect of extremely high and humid

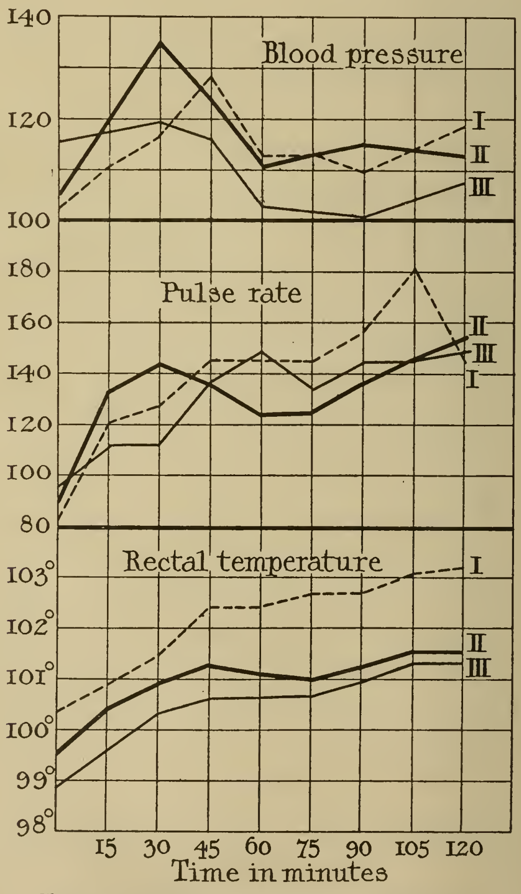

Chart of Walking Experiment. (See text.)

heat was investigated upon three subjects, with a view to comparing the physiological effects produced by external heat alone with that produced by exercise in a hot climate. A small chamber of galvanised iron was used as a hot room. The iron was exposed to the direct sun's rays, and additional moist heat was produced by boiling water within the chamber; on sunny days a wet bulb temperature of about 102° F. could be obtained. The results are tabulated separately in Table VII.

In all experiments observations were made upon the changes of pulse rate, blood pressure, body temperature, and carbon dioxide content of the alveolar air. The pulse was counted for several quarter-minute periods, and in general the pulse rate of the subject in a lying position was contrasted with that of the subject standing up.

The blood pressure was estimated by means of a Tycos sphygmo-manometer, which instrument had been checked against a mercury manometer. The body temperatures recorded denote invariably rectal temperatures. The alveolar air was sampled by the Haldane-Priestley method.

Pulse Rate.—The pulse rate (Table I) in the subject at rest was within the range considered normal for a temperate climate, varying between 68 and 98 per minute. The pulse rate determined in an upright and recumbent position showed now and again a considerable difference, being lower in several of the subjects when lying down; considerable individual variations in this respect were noted.

The increase caused by exercise corresponded roughly with the violence of the effort, and in those experiments in Table I where the subject raced up and down stairs, the rise accorded with the length of time taken in performing the task. The pulse rate began to fall again immediately the exercise was discontinued, rapidly at first and more slowly afterwards, and after five minutes or so the pulse rate was still above the rate at rest.

In the walking exercises, extending over a prolonged period, the pulse rate at the end of the experiment was, as a rule, high, and it took a much longer time to return to the original rate. In a few instances the pulse rate was determined after half the walk had been accomplished, and it was observed that during the second half of the exertion practically no further rise was produced. In the special walking experiment (see chart) the pulse of the subjects I and II showed a rapid and marked rise at first; afterwards the pulse rate continued to rise at a much slower rate, or exhibited only insignificant variations.

In the hot room experiments the pulse rate rose very slowly and gradually concomitantly with the body temperature.

Blood Pressure.—The results of the estimations of blood pressure are

Table I.

No.	Subject.	Nature of exercise.	Pulse rate at rest.		Pulse rate after exercise.			
			Standing.	Lying.	Calculated from first 15 secs.	Counted during first min.	Counted in successive periods of 15 secs.	Rate after mins. counted in 15 sec. period.
1	I.	Running up and down stairs— 10 times in 155 secs.	80	—	128	124	32, 32, 28, 30, 30, 28, 27, 27	3 mins. 26; 18 mins. 23.
2		10 " 121 "	76	68	148	137	37, 34, 34, 32, 31, 31, 30, 28	5 " 25; 9 mins. 23.
3		10 " 129 "	72	72	136	126	34, 33, 30, 29, 29, 27, 27	5 " 25.
4		10 " 125 "	80	75	148	138	37, 35, 34, 32, 29, 28, 28	10 " 24.
5		10 " 127 "	74	72	148	133	37, 35, 32, 29, 29, 27, 27, 25	6 " 25.
6		10 " 123 "	76	72	160	143	40, 37, 34, 32, 29, 27	5 " 24.
7		10 " 118 "	70	68	176	152	44, 40, 36, 32	5 " 24.
8	II.	10 " 152 "	96	75	164	149	41, 37, 36, 35, 32	5 " 28; 8 mins. 25.
9		10 " 133 "	84	80	172	157	43, 40, 37, 37, 33, 32, 32, 30	5 " 26.
10		10 " 138 "	94	80	168	143	42, 37, 34, 30, 32, 30, 29	7 " 26.
11		10 " 130 "	98	80	164	151	41, 38, 37, 35, 32, 30	5 " 24.
12		10 " 123 "	84	69	144	141	36, 35, 35, 35, 32, 29, 30, 28	5 " 24.
13		10 " 118 "	90	78	164	148	41, 38, 35, 34, 31, 30, 30	5 " 23.
14	III.	7 " 90 "	80	76	164	153	41, 39, 37, 36, 37, 33, 33	4 " 29; 13 mins. 28.
15		8 " 125 "	78	72	172	158	43, 42, 37, 36, 35	5 " 26.
16		8 " 115 "	80	76	160	148	40, 36, 36, 36, 35, 34	5 " 30.
17		8 " 118 "	82	74	172	160	43, 41, 40, 36, 35, 35, 32, 30	5 " 26.
18		8 " 120 "	82	72	160	148	40, 36, 37, 35, 33, 32	5 " 25.
19		9 " 141 "	78	66	164	154	41, 40, 38, 35, 33, 32	5 " 27.
20	IV.	10 " 130 "	80	80	160	145	40, 37, 34, 34, 34	5 " 30
21		10 " 150 "	72	72	140	125	35, 32, 30, 28, 26, 26, 24	6 " 22.
22		10 " 157 "	70	70	140	128	35, 32, 31, 30, 29, 27	5 " 20.
23		10 " 155 "	74	64	148	132	37, 34, 32, 29, 28, 24	5 " 19.
24		10 " 149 "	96	82	120	113	30, 29, 27, 27, 26, 24	5 " 24.
25		10 " 142 "	84	70	152	127	38, 34, 29, 26, 22	5 " 21.
26	V.	10 " 135 "	88	72	156	138	39, 36, 32, 31, 30, 30, 29, 28	5 " 25.
27		10 " 148 "	80	66	144	123	36, 31, 29, 27, 27, 26	5 " 26.
28		10 " 135 "	68	60	152	131	38, 34, 30, 29, 27, 26, 25, 24	5 " 24.

29		10 times in 130 secs.	80	68	164	147	41, 37, 35, 34, 34	5 mins. 25.
30	VI.	10 ,, 117 ,,	80	76	152	125	38, 38, 27, 22, 23, 23	5 ,, 25.
31		10 ,, 117 ,,	78	78	148	123	37, 35, 27, 24, 23	5 ,, 25.
32		10 ,, 110 ,,	94	82	180	129	45, 29, 28, 27, 27	5 ,, 25.
33	I.	Walking for 36 mins.	80	76	128	120	32, 31, 28, 29, 29	10 ,, 24.
34		Walking for 37 mins. 2nd walk of 33 mins.	74 —	72 —	140 160	— 133	35, 34. 40, 35, 30, 28	20 ,, 27.
35	II.	Walking for 30 mins. 2nd walk of 32 mins.	92 —	80 —	160 164	— —	40, 39. 41, 38, 36	4 ,, 34.
36	IV.	Walking for 34 mins. 2nd walk of 36 mins.	88 —	74 —	140 144	— 126	35, 32, 32. 36, 32, 30, 28, 25, 27, 27.	
37	V.	Walking for 38 mins. 2nd walk of 38 mins.	80 —	68 —	140 132	123 119	35, 32, 28, 28. 33, 30, 28, 28, 26.	
38	II.	Climbing hill 1000 feet	84	—	148	—	37, 34, 33.	
39	III.	Climbing hill 1000 feet After descending same	84 —	— —	180 160	— —	45, 38, 37. 40, 39.	

recorded in Table II. The figures indicate that the blood pressure was raised to a greater extent by violent exercise of short duration than by a prolonged and less strenuous effort. In the former series of experiments the blood pressure began to fall immediately after the cessation of exercise, and returned within a comparatively short time (about ten minutes) to the original. In the case of prolonged exercise the blood pressure rose at first considerably, and afterwards continued to rise very gradually or even remained stationary. In some instances the initial rise was followed by a fall to the normal, or sometimes even to a sub-normal figure. The curves in the chart illustrate this fact clearly. This fall in pressure is probably due to the dilatation of the cutaneous blood vessels brought about by the high temperature of the skin.

Table II.

No.	Subject.	Nature of exercise.	Blood-pressure (mm.).		
			Before.	Immediately after exercise.	After *n* minutes.
		Running up and down stairs—			
1	I	10 times in 129 secs.	109	152	5 mins. 139 ; 13 mins. 115
2		10 ,, 123 ,, ...	105	162	5 ,, 126.
3		10 ,, 118 ,, ...	108	140	5 ,, 125.
4	II	10 ,, 152 ,, ...	112	172	8 ,, 122.
5		10 ,, 132 ,, ...	106	140	5 ,, 114.
6		10 ,, 118 ,, ...	110	145	5 ,, 123.
7	III	7 ,, 90 ,, ...	119	143	5 ,, 122.
8		8 ,, 125 ,, ...	112	162	3 ,, 146 ; 5 mins. 130. 8 mins. 108.
9		8 ,, 118 ,, ...	110	148	5 ,, 126.
10	IV	10 ,, 130 ,, ...	137	186	5 ,, 172 ; 8 mins. 140.
11		10 ,, 150 ,, ...	147	178	2 ,, 157 ; 5 mins. 142.
12		10 ,, 155 ,, ...	129	192	5 ,, 128.
13		10 ,, 142 ,, ...	132	162	5 ,, 130.
14	V	10 ,, 135 ,, ...	124	148	5 ,, 130.
15		10 ,, 130 ,, ...	122	170	5 ,, 135 ; 10 mins. 128
16	VI	10 ,, 117 ,, ...	126	185	5 ,, 152.
17		10 ,, 110 ,, ...	141	176	5 ,, 132.
18	I	Walking 36 mins.	109	129	15 ,, 110 ; 45 mins. 109
19		,, 37 ,, ...	119	130	
		Second walk in 33 mins.	—	148	20 ,, 118.
20	II	Walking 30 mins.	113	137	
		Second walk in 32 mins.	—	130	5 ,, 112.
21	IV	Walking 34 mins.	139	153	
		Second walk in 36 mins.	—	130	
22	V	Walking 38 mins.	112	132	
		Second walk in 38 mins.	—	128	
23	I	Climbing hill (1000 feet)	109	134	
		Descending same..................	—	118	
24	II	Ditto	110	135	
			—	123	
25	III	Ditto	112	102	
			—	102	

The observations upon the effect of humid heat alone upon the blood pressure were only carried out on two subjects, and gave inconsistent results. In some instances the blood pressure of one of the subjects rose, whereas it fell to a slight extent with the other. Hill and Flack (1909) on the other hand, observed a constant and considerable fall in the blood pressure after a stay of fifteen minutes in a hot bath of 100° to 112° F.

Body Temperature.—Previous observers have proved that the rectal temperature may rise to as much as 102° F. in perfectly healthy individuals as the result of moderate exercise in a temperate climate, and Hill and Flack have recorded even much higher temperatures in athletes. In one individual, for example, a temperature of 105° was recorded after a foot-race over a course of three miles, and these authors drew attention to the fact that the temperature rose with the duration of the effort.

In the present experiments exertion of short duration did not produce any rise of any consequence; 0·3°–0·8° F. was the usual elevation, and only on one occasion (subject VI) a rise of 2° was found.

Table III.

No.	Subject.	Nature of exercise.	Air temperature.		Rectal temperature.	
			Dry bulb.	Wet bulb.	Before exercise.	After exercise.
1	I	Walking 36 mins.	86·6	72·2	99·6	100·9
2		" 37 "	87·3	76·0	99·4	101·3
		2nd time in 33 mins.	—	—	—	102·0
3	II	Walking 30 mins.	88·1	79·8	99·7	102·7
		2nd time in 32 mins.	—	—	—	103·0
4	IV	Walking 34 mins.	85·0	76·2	99·8	101·8
		2nd time in 36 mins.	—	—	—	102·0
5	V	Walking 38 mins.	84·2	74·3	99·9	101·3
		2nd time in 38 mins.	—	—	—	101·6
6	I	Walking 2½ hours	80·1	78·2	100·3	101·9
7		" 3½ "	85·2	75·3	99·8	101·4
8		" 2 "	86·4	81·0	100·3	103·1
9	II	" 2½ "	80·1	78·2	99·8	101·2
10		" 3½ "	85·2	75·3	99·5	100·6
11		" 2 "	86·4	81·0	99·5	101·4
12	III	" 2 "	86·4	81·0	98·8	101·3
13	VII	" 2½ "	80·1	78·2	100·0	100·9
14		" 3½ "	85·2	75·3	99·6	101·0
15	I	Climbing hill (1000 feet)	86·2	78·1	99·6	102·0
16	II	" " "	86·2	78·1	99·7	102·0
17		" " "	85·0	75·5	99·5	101·4
18	III	" " "	86·2	78·1	99·2	103·3

Prolonged and less vigorous exertion—such as walking or hill-climbing during the hot hours of the day—caused much higher rectal temperatures, and the increase was more marked during the first part of the exercise than later. For example, in the experiments where the rectal temperatures were taken half-way through the walk, the rise during the first part amounted to 2° or 3° F., whereas it was only further increased by two or three-tenths of a degree after the repetition of the effort. The chart contains a graphic representation of the rectal temperatures during a two hours' walk on a hot day, and illustrates the above statement.

In the hot room a continued rise in rectal temperature was noted. This took place in the beginning slowly and gradually, but the rate increased with time and with increased temperature, thus confirming Haldane (1905), and Harvey Sutton's (1908) observations.

Alveolar air.—The percentage of carbon dioxide in the alveolar air has been estimated by a number of observers by the Haldane and Priestley method, and their results on individuals at rest have been found fairly constant. In Table IV are given the averages of 58 observations on seven subjects at rest, whereas Table V gives for comparison averages, maxima and minima, obtained by other workers in Europe. The figures obtained in Townsville are lower than those of the other authors, and this may be attributed to the influence of the higher temperatures of the atmosphere.

Table IV.—Alveolar Air during Rest.

Subject.	No. of observations.	Carbon dioxide percentage.		
		Average.	Maximum.	Minimum.
I.	8	4·58	4·96	4·03
II.	34	5·04	5·45	4·71
III.	4	4·76	5·0	4·60
IV.	3	5·33	5·86	5·01
V.	3	5·08	5·53	4·48
VI.	1	5·25	—	—
VIII.	5	4·77	4·95	4·50
Mean	58	4·99	—	—

Table V.

Observer.	No. of subjects.	Carbon dioxide in alveolar air.		
		Mean.	Maximum.	Minimum.
Haldane and Fitzgerald (1905)	27	5·59	6·34	4·72
Hill and Flack (1909)	17	5·32	6·35	4·05
Cook and Pembrey (1913)	10	5·57	6·11	4·87
Present observations	7	4·99	5·86	4·03

In this connection it has been noticed by Boycott and Haldane (1908) that outer temperatures influence the carbon dioxide in the alveolar air, and that there existed in fact a seasonal variation, higher percentages being found in cold and lower in warm weather. They do not believe, however, that these changes are caused by variations in the body temperature, but are solely due to the effect of contact of the face and hands with cold or warm air. Lower averages than the European figures were obtained by Chapman and Wardlaw (1916) working in Sydney, and Chapman has stated that he has never obtained a maximum higher than 6 per cent., which in his opinion is due to the higher average outer temperatures in Sydney.

Table VI contains the details of analyses of alveolar air after various forms of exercise. The percentage of carbon dioxide in general was greatly increased. After prolonged exercise the increase was much less marked than after vigorous exercise, and in experiments where an analysis was made halfway through the experiment the increase was more marked in the first than in the second half. In several experiments the analysis after exercise showed an actual decrease when compared with the figure at rest, which decrease may be attributed, as previously explained by Cook and Pembrey

Table VI.

No.	Subject.	Nature of exercise.	CO_2 per cent. in alveolar air.	
			Before.	After.
1	I.	Short vigorous 121 secs.	4·56	7·16
2		„ 125 „	4·39	7·28
3		„ 127 „	4·86	6·93
4	II.	„ 133 „	4·82	6·03
5		„ 138 „	5·02	5 63
6		„ 133 „	4·83	5·43
7	III.	„ 105 „	4·62	5·33
8		„ 120 „	4·60	5·40
9		„ 141 „	4·82	6·15
10	IV.	„ 151 „	5·12	7·12
11		„ 149 „	5·01	6·96
12	V.	„ 148 „	4·48	8·32
13		„ 135 „	5·53	8·16
14	VI.	„ 117 „	5·25	9·05
15	I.	Walking 36 mins.	4·66	5·38
16		„ 37 „	4·82	5·27
		2nd time in 33 mins.	—	5·44
17		Up and down hill 48 mins.	4·40	4·15
18	II.	Walking 30 mins.	5·03	4·26
		2nd time in 32 mins.	—	4·65
19		Up and down hill 48 mins.	5·01	4·08
20	III.	„ „ „	5·0	3·50
21	IV.	Walking 34 mins.	5·86	6·58
		2nd time in 36 mins.	—	5·95
22	V.	Walking 37 mins.	5·23	6·52
		2nd time in 38 mins.	—	6·62

(1913) to the washing out of carbon dioxide from the lungs by the vigorous ventilation.

In the hot room experiments the percentage of carbon dioxide did not show any constant variation, whereas Hill and Flack (1909) in their hot-bath experiment, observed a marked decrease in the carbon dioxide tension, owing to the increased rate of respiration due to the heat.

Loss in body weight.—The temporary loss in body weight brought about by exercise, and which is mainly due to loss of water, is naturally considerable in the tropics, on account of the increased perspiration. As shown in Table VII the loss bears relationship to the effort, time, and external heat. It was quite a common occurrence to lose as much as 1 kgrm. in weight during a walk of one hour at a moderate pace, and in one instance as much as 3200 grm. (Experiment No. IV in Table) was lost during a two hours' walk. The loss of weight in the hot room amounted to between 500 and 1200 grm. in one hour. In several exercise experiments quoted in the Table, the subjects were weighed in their clothing so that the loss represents only the water evaporated and not the total water lost from the body.

The loss of weight represents in the main loss of water secreted as perspiration; a certain amount of water is lost in the expired air, but as the air inspired is not far from the saturation point this amount is small. The loss in weight due to respiratory exchange may be neglected.* In the hot room, where the humidity was very high, practically the total loss in weight is due to perspiration.

The question as to the source from which the perspiration is derived has been discussed by Hunt (1912), who estimated the percentage of hæmoglobin in the blood before and after prolonged sweating in a hot room. He found that the hæmoglobin figures remained constant, and concluded from this that no concentration of the blood had taken place and that therefore the water excreted in the sweat was derived from the tissues and not from the blood serum. A similar experiment was carried out by Haldane and Priestley (1916)

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* In the course of another investigation by one of us (W. J. Y.) the respiratory exchange of two of the subjects was determined by means of a Zuntz portable meter, during a walk of 15 minutes at a rate of 3 miles per hour, and the figures obtained may be quoted here to show that only an insignificant portion of the weight lost is accounted for in this way.

In this experiment carbon dioxide was evolved at the rate of 107 and 119 grm. per hour by the two subjects respectively, and oxygen absorbed at the rate of 96 and 108 grm. per hour. The loss in weight due to respiratory exchange was therefore only 11 grm. per hour in each case.

In another experiment, one subject during an hour in the hot chamber lost about 7 grm. in weight due to the respiratory exchange.

Table VII.

No.	Subject.	Temperature of room.		Rectal temperature.		Pulse rate.				Blood-pressure.		Alveolar CO_2.		Duration of experiment.
		Dry bulb.	Wet bulb.	Before.	After.	Before lying.	Before standing.	After lying.	After standing.	Before.	After.	Before.	After.	
1	I	100 ·1 to 101 ·2	95 ·8 to 98 ·0	100 ·1	102 ·2	—	76	—	124	120	123	4 ·96	4 ·04	mins. 60*
2		100 ·1 „ 100 ·8	96 ·1 „ 97 ·3	100 ·3	102 ·7	84	88	89	128	109	100	4 ·03	4 ·05/4 ·23	70†
3		100 ·1 „ 107 ·0	98 ·7 „ 102 ·0	99 ·8	102 ·0	—	—	—	132	—	—	—	—	40‡
4		93 ·0 „ 95 ·0	88 ·5 „ 92 ·0	99 ·8	100 ·2	—	—	—	—	—	—	—	—	60
5		96 ·2 „ 97 ·1	91 ·2 „ 95 ·2	99 ·5	100 ·4	66	74	62	78	110	103	—	—	60
6	II	94 ·8 „ 100 ·3	98 ·2 „ 96 ·0	99 ·5	103 ·0	72	72	112	168	112	142	—	—	78§
7		102 ·1 „ 104 ·1	93 ·0 „ 96 ·2	99 ·5	100 ·8	—	88	—	116	—	—	—	—	45
8		100 ·3 „ 99 ·0	93 ·0 „ 96 ·7	99 ·2	101 ·4	—	86	—	132	—	—	—	—	60
9		101 ·4 „ 99 ·8	96 ·1 „ 98 ·8	99 ·8	102 ·8	—	98	—	130	103	118	—	—	60
10	VII	106 ·0 „ 108 ·0	92 ·0 „ 95 ·0	99 ·7	100 ·8	—	90	—	128	—	—	—	—	60

* Throbbing in head.

† S.G. of blood—before 1 ·0535, after 1 ·0567.

‡ Fainting.

§ S.G. of blood—before 1 ·0515, after 1 ·0552.

who failed to detect any alteration in the percentage of hæmoglobin in the blood after a net loss of 1·07 kgrm. in body weight.

Experiments were undertaken to ascertain whether the estimation of the specific gravity of the blood might yield further information on the source of the sweat. Observations on the specific gravity of the blood were carried out some time ago in this Institute by Hammerschlag's chloroform-benzene method and yielded figures well within the range of European estimations. The same method was employed to estimate the specific gravity of the blood before and after profuse sweating, in order to ascertain whether any concentration could be detected by this means. Although the estimations showed a very slight increase in the specific gravity of the blood after sweating in the hot room, the differences were within the range of experimental error, which is considerable. Unless a mixture of the same specific gravity as that of the blood were hit upon immediately it was difficult to obtain a constant behaviour of a drop of blood; moreover the size of the drop had an undoubted effect upon the result. For the above reasons this method was abandoned, and in the later experiments the total solids of the blood before and after the sweating and the refractive index of the blood serum were estimated.

For the total solids a few drops of blood oozing out freely from a deep puncture wound in the lobe of the ear were collected on a small piece of thick blotting paper, previously dried and tared. It was quickly weighed and dried to constancy at 110° C. The amount of blood collected weighed about 120 mgrm. to 130 mgrm., and the weighings were done by a specially constructed micrometer balance, designed and made by Messrs. Felton, Grimwade and Company of Melbourne, accurate to 1 mgrm., which enabled the paper to be weighed in a few seconds; the whole determination could thus be completed in 15 to 20 minutes. All estimations were done in duplicate.

The method was not found altogether reliable on account of the possible sources of error. If the blood did not flow freely from the puncture wound and pressure had to be resorted to, the estimations of the blood solids gave inconsistent results. In addition, there was always the possibility of a small amount of sweat being taken up simultaneously with the blood by the paper.

In spite of these possible errors, after a few preliminary experiments duplicate estimations gave fairly consistent results, and the calculated percentage of the total solids in the blood (about 20 per cent.) from two separate estimations did not differ by more than one.

The total solids in the blood showed a decided tendency towards increase after perspiring; out of 11 experiments, in six the increase was larger than the experimental error, varying between 1·5 and 3·1. In three experiments there was an increase, but within the error limit, and an actual but small decrease was observed in two experiments. The increase in the blood solids in the different experiments was not proportionate to the loss in body weight. In the detailed Table a column is given indicating the loss of water from the blood, which would correspond to the increase in the solids actually observed. Considering the small actual difference in the weighings, these calculations are only very approximate, and only the one conclusion is justified—that there is a tendency to increased blood solids brought about by copious sweating.

The refractive index of the serum was measured before and after copious perspiration. The blood was collected from the ear by means of a Wright's tube, allowed to clot and centrifugalised, and the serum examined by means of a Zeiss-Abbé refractometer. In a few instances serum of blood obtained from the ear and from the finger were compared and yielded identical results. In every case the refractive index of the serum was higher after profuse sweating, whether brought about by exercise or merely by exposure to excessive moist heat as shown in Table VII.

In the Table a column of figures is given which represents the percentage of water lost from the blood, calculated from the increase in the refractive index. The figures were arrived at in the following manner: A series of weighed quantities of goat's blood was allowed to evaporate slowly in a desiccator over sulphuric acid, and the increase in the refractive index of the serum was then plotted against the corresponding loss of water from the blood, and a curve smoothed through the points. From this curve the percentage of loss of water from the blood corresponding to the increase in the refractive index of the serum could be obtained.

On comparing the total loss in body weight with the calculated loss of water from the blood, based on the refractive index of the serum, it is clear that the greater part of the sweat must be derived from other sources than the blood, although the experiments show that at least part of the fluid lost is derived from the blood plasma.

It will be observed also from the Table that the quantity of water lost from the blood, as calculated from the refractive index, and that estimated from the increase in the total solids of the blood, do not agree, but, as pointed out previously, the errors in estimating the total solids were too great to consider this method more than a qualitative one.

The estimation of the refractive index gave such constant results that one must conclude that a definite concentration of the blood does take place as the result of copious sweating. The percentages, however, seem rather high,

Table VIII.

No.	Subject.	Nature of experiment.	Air temperature.		Body weight.	Loss.	Refractive index of serum.				Blood solids.			
			D.B.	W.B.			Before.	After.	Increase.	Water loss.	Before.	After.	Change.	Water loss.
					kilog.	grm.				p. c.	p. c.	p. c.	p. c.	p. c.
1	I.	Walking 36 mins.	86·6	72·2	69 clothed	750								
2		„ 37 „	87·3	76·0	68·8 „	610								
		2nd time in 33 mins. ...	—	—	—	550								
3		Climbing hill, 1000 feet	86·2	78·1	69 clothed	950								
4		Walking 2 hours	86·4	81·0	68 naked	3200								
5	II.	„ 30 mins.	88·1	79·8	48 clothed	300								
		2nd time in 32 mins. ...	—	—	—	440								
6		Climbing hill	86·2	78·1	47·6 clothed	560								
		Walking 2 hours	86·4	81·0	44·8 naked	1500								
8	III.	Climbing hill	86·2	78·1	79·3 clothed	1030								
9		Walking 2 hours	86·4	81·0	74·2 naked	2500								
10	IV.	Walking 34 mins.	85·0	76·2	61·25 clothed	400								
		2nd time 36 „	—	—	—	480								
11	V.	Walking 38 „	84·2	74·3	59·95 clothed	500								
		2nd time in 38 mins. ...	—	—	—	400								
12	I.	Hot chamber 60 mins. ...	100·6	96·9	67·25 naked	1540								
13		„ 60 „ ...	100·3	96·8	67 „	2000								
14	II.	„ 80 „ ...	97·7	92·1	45·4 „	650								
15		„ 60 „ ...	99·6	93·5	45 „	500								
16	I.	Walking 2½ hours	80·1	78·2	67 „	1530	1·3477	1·3481	0·0004	4·2	20·2	21·0	+0·8	3·8
17		„ 3½ „	85·2	75·3	67 „	2733	1·3469	1·3485	0·0016	8·8	19·2	22·2	+3·0	13·5
18	II.	Climbing hill	85·0	75·5	45 „	700	1·3470	1·3479	0·0009	6·9	22·2	20·7	−1·5	
19		Walking 2½ hours	80·1	78·2	45 „	693	1·3468	1·3478	0·0010	7·2	20·3	19·4	−0·9	
20		„ 3½ „	85·2	75·3	45 „	1502	1·3474	1·3482	0·0008	6·7	18·1	20·3	+2·2	10·8
21	VII.	Climbing hill	85·0	75·5	89 „	1265	1·3476	1·3480	0·0004	4·2				
22		Walking 2½ hours	80·1	78·2	89 „	1440	1·3467	1·3475	0·0008	6·7	20·4	21·9	+1·5	6·9
23		„ 3½ „	85·2	75·3	89 „	2730	1·3460	1·3480	0·0020	9·5	20·3	21·3	+1·0	4·7
24	I.	Hot chamber 35 mins. ...	107·0	100·3	67 „	1220	1·3473	1·3482	0·0009	6·9	19·0	21·4	+2·4	11·2
25		„ 60 „ ...	94·0	91·1	67 „	595	1·3475	1·3480	0·0005	5·0	19·2	20·2	+1·0	5·0
26	II.	„ 45 „ ...	102·9	94·6	45 „	506	1·3462	1·3470	0·0008	6·7	18·5	20·6	+2·1	10·2
27	VII.	„ 60 „ ...	101·0	93·5	89 „	970	1·3469	1·3481	0·0012	7·8	17·5	20·6	+3·1	14·8

and in all probability the calculated percentages can only be regarded as rough approximations.

These results thus differ from those of Hunt, who was unable to detect any loss of water from the blood by means of hæmoglobin estimation, but bear out his contention that the bulk of water in the sweat is derived from the tissues. As an additional source of water, the intestinal canal must be kept in mind.

Summary.

1. Vigorous exercise of short duration caused—

   (*a*) An increase in the pulse rate and blood pressure, both of which rapidly fell to normal after discontinuation of the exercise.

   (*b*) An increase in the carbon dioxide percentage of the alveolar air.

2. The alveolar air at rest in inhabitants of tropical Queensland showed a lower carbon dioxide content than the European average.

3. Prolonged exercise led to a rapid increase in the pulse rate and temperature at first, which increase became more gradual afterwards, and in the case of blood pressure even fell on occasions below normal, on account of the profuse sweating. Prolonged exercise had but little effect on the alveolar air.

The body temperature during the exercise continued to rise slowly, but, considering the light nature of the exercise, the rise in temperature was considerable.

4. A considerable loss of water from the body was observed as the result of prolonged exercise. Blood estimations showed that this water was mainly derived from other sources in the organism than the blood plasma; a small concentration of the blood plasma, however, had taken place.

5. The hot room experiments gave results similar to those caused by prolonged exercise, with this difference, that the pulse rate and body temperature rose more gradually at first, but a quicker rise took place afterwards.

6. The results point to the fact that both exercise and humid heat play a part in producing a rise in blood pressure, pulse rate, and rectal temperature. The degree of rise, however, is controlled by atmospheric conditions which influence the rate of cooling of the body.

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THE METABOLISM OF WHITE RACES LIVING IN THE TROPICS

III. THE INFLUENCE OF EXTERNAL TEMPERATURE AND RATE OF COOLING UPON THE RESPIRATORY METABOLISM

BY

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A considerable amount of attention has been devoted to the question whether the human organism responds to changes in external temperature by changes in the quantity of heat produced; that is to say, whether changes in the heat production play any part in maintaining a constant body temperature. The action of low temperature has been studied by Loewy (1890), Johansson (1896), Rubner and Lewaschew (1897), and others, by observing the respiratory metabolism under different conditions, and the results point to the conclusion that an increased metabolism is only produced when the cold is sufficient to stimulate the muscles to voluntary or involuntary action, and to cause shivering. The increased metabolism produced on a cold day is due, therefore, to the cold air acting on the skin and producing an increased muscular activity or tone.

With regard to high external temperatures, such as exist in the tropics, the question is of considerable interest as to whether the body adapts itself to the altered conditions by a decrease in its heat production, or whether the temperature is regulated entirely by heat loss, i.e., by physical means.

A summary of the work done on the subject of metabolism in the tropics from this point of view has been given by Breinl and Young (1919) in an article on the settlement of Tropical Australia. The general results of these investigations are that a decrease in heat production does not play any important part in the maintenance of body temperature.

The action of high temperatures and humidity upon the respiratory gas exchange has been investigated mostly under artificial conditions in a temperate climate, and the results are not very definite, and in some cases contradictory. Briefly all that can be said is that there appears to be an ill-defined zone of temperature, about 15° to 25° C. (59° to 77° F.) in which the metabolism is at a minimum.

The effects of extreme humid heat upon the respiratory metabolism have been studied by Harvey Sutton (1908). When the wet bulb temperature of the surroundings rose above a critical point, as previously shown by Haldane, so that no evaporation of sweat could take place, the body temperature rose, and this caused an increased metabolism and corresponding increased production of heat, which again further increased the body temperature; a vicious circle was thus established, resulting in a gradually increasing rate in the rise of body temperature, until dangerous conditions were reached.

Eijkman (1896), working under natural conditions actually in the tropics, determined the respiratory exchange of eleven Europeans and twelve Malays, and compared the average amount of oxygen consumed and carbon dioxide expired with the averages obtained by workers in Europe. Using the Zuntz-Geppert method, he obtained, as the result of thirty-seven experiments on Europeans and forty-eight on Malays, an average of 245·7 c.cs. of oxygen absorbed per minute by the Europeans, and 215·5 by the Malays; these he compared with figures obtained by the same method in Europe by Geppert, Loewy and others, namely, 250·3 c.cs. per minute. In both cases the numbers are calculated to a body weight of 64 kilograms. He concluded from these that there was no evidence of any decreased heat production. It is obvious that the number of experiments is far too small to draw definite conclusions.

Observations were carried out, also under natural conditions, by Osborne (1912) during the summer in Victoria, Australia, where the temperature frequently rises above 100° F., and he found a decided increase with the higher external temperatures, both in the pulmonary ventilation and in the carbon dioxide produced.

The reaction of the metabolism to surrounding conditions has been investigated recently by Hill and his colleagues (1914) in England, by determining the respiratory exchange from day to day under natural conditions, and co-ordinating the changes he observed not with the actual air temperature, but with the cooling power of the atmosphere as determined by the katathermometers, two thermometers with large bulbs filled with alcohol. This instrument was invented by Hill to measure the rate of cooling due to atmospheric conditions on a body at a temperature in the neighbourhood of that of the human body. The two instruments employed (dry and wet bulb katathermometers) give the rate of cooling, the dry one by convection and radiation, and the wet by convection, radiation and evaporation. He found that in experiments done in the open air, the greatest metabolism took place on days on which the greatest rate of cooling was observed. He also found that in experiments done indoors where the rate of cooling was low, the metabolism was very markedly less than outdoors upon the same day, provided that the cooling power outdoors was very much higher than indoors. In short, the metabolism ran parallel with the cooling power of the atmosphere, and not with the actual temperatures as observed with the ordinary dry and wet bulb thermometers. He attributes the efficacy of the open air treatment of pulmonary complaints to the increased metabolism produced by the greater degree of cooling outside.

The present paper contains the results of experiments extending over three years, the subjects living in the tropics (19° South), with the object of investigating the changes in the respiratory metabolism under different atmospheric conditions. Observations have been carried out in the hot season of the year (November to May) and in the cooler season (June to October). In these experiments a similar procedure was followed to that of Hill, the cooling power of the atmosphere being observed by means of the katathermometers as well as the temperatures with the ordinary dry and wet bulb thermometers.

The writer wishes to acknowledge his indebtedness to Mr. J. W. Fielding, chief assistant of this Institute, who not only acted as one of the subjects, but helped with the various observations recorded.

METHODS EMPLOYED

The subject lay at ease in a deck chair, with a foot rest, and remained without movement during the experiment. The usual canvas of the chair was removed and replaced by a covering made from an open-mesh string hammock, so that the body should be freely exposed on all sides. After lying for about thirty minutes, the subject breathed for exactly twenty minutes through a mouthpiece fitted with inspiratory and expiratory valves into a Zuntz portable respiration meter, the nose being closed by means of a spring clip. The meter was previously tested by driving through it a known volume of air from a large aspirator at the rate of between 5 and 6 litres per minute, and a correction determined from the mean of a large number (100) of such tests, and applied to the volume of expired air in each experiment. This correction was very small, amounting to an addition of 2 c.c. per 100 c.c. measured. Certain modifications were employed in collecting the sample of expired gases for analysis. A mixing vessel was interposed between the mouthpiece and the meter, as recommended by Bohr (see Krogh (1916)), consisting of a cubical metal box of about 2 litres capacity. The sample was drawn out through the usual opening attached to the small box at the top of the meter, but the proportionate sampling arrangement employed by Zuntz was replaced by a gas sampling tube as designed by Huntly (see Haldane (1912)), which allowed of the sample being collected at an even rate over the whole period, merely by allowing the mercury with which the sampling tube was filled to run out through an exit tube of a suitable bore so as to collect about 180 to 200 c.c. in the time. The water acidulated with sulphuric acid, used by Zuntz, was thus dispensed with, as it was found that this absorbed a small quantity of carbon dioxide, especially if the analysis were postponed for any time. The sample was analysed by means of the Haldane apparatus, at least two analyses of each sample being performed.

Table I shows a series of pairs of observations, done at different times to test the method, each pair consisting of consecutive twenty minutes' breathing into the meter. The two observations were substantially the same in each case.

TABLE I.

Subject	Vol. of expired air Litres per 20 min.	Analysis of expired Air		CO$_2$ eliminated c.c. per min.	O$_2$ consumed c.c. per min.	Resp. Quot.
		CO$_2$ %	O$_2$ %			
W. J. Y. (1)	110	3·66	16·50	199	254	0·78
	112	3·69	16·51	205	260	0·79
(2)	108	3·49	16·74	186	236	0·79
	111	3·37	16·55	197	250	0·79
(3)	87·5	3·72	16·28	161	214	0·75
	86·0	3·80	16·09	162	220	0·74
J. W. F.	120	3·67	16·82	217	253	0·86
	116	3·58	16·89	205	241	0·85

Whilst the breathing was going on, the following observations were made by the assistant at the beginning, half-way through, and at the end of the time, and the averages of the readings so obtained taken as the figure for the whole time:—

1. The readings of the ordinary dry and wet bulb thermometers.
2. The temperature of the expired gases in the meter.
3. The temperatures, taken with dry and wet bulb thermometers, of the air between the skin and the clothing (called by Hill skin-shirt temperatures).
4. The times taken for the dry and wet bulb katathermometers to cool from 110° to 100° F. and 100° to 90°. As a rule, only one determination was made with the dry bulb instrument, as the time taken was generally too long to allow of a series of observations.
5. The pulse rate was noted, and the rectal temperature of the subject was taken before and after each experiment. The pulse rate did not show any great variations, the two extremes with W. J. Y. being 64 and 76 per minute, and with J. W. F. 60 and 70 per minute.

The volume of expired gases was calculated dry to 760 mm. pressure and 0° C., and for the calculation of the oxygen absorbed, a correction was made for the difference in volume of inspired and expired air as given by Haldane (1912). The percentages of oxygen and carbon dioxide in the inspired air were taken as 20·90 and 0·03 respectively, the figures given with outside air by the Haldane gas analysis apparatus employed in the experiments.

The experiments were carried out on two subjects, W. J. Y., 38 years at commencement and 45·4 kilograms in body weight, and J.W.F., 27 years and 56·2 kilograms body weight, and were always done in the mornings about the same time after breakfast. Neither subject altered in weight during the whole period by more than a few tenths of a kilogram. A number of preliminary experiments were performed in order to get the subjects accustomed to the mouthpiece.

In all but a few experiments the same amount of clothing was worn, consisting of a light shirt, cotton trousers, socks and shoes. Most of the experiments out of doors were carried out in the shade of a large mango tree, and a few on the verandah of the first storey of the Institute. The accompanying tables give the details and results of the experiments.

AIR TEMPERATURE

The climate in the coastal districts of North Queensland is monsoonal, and the rains occur during the hot months of the year (November to April), during which time the readings of the wet bulb thermometer are very high, and typical moist tropical weather is experienced. During the hot season the outside dry bulb temperatures lay between 80° and 91° F. (26·7° and 32·8° C.), and the wet bulb was with a few exceptions always between 75 and 80° F. (23·9° and 26·7° C.), whilst higher wet bulb temperatures (over 80° F.) were observed indoors. In the cooler season experiments were carried out with much lower air temperatures, the lowest dry bulb reading being 62·8° F and the lowest wet bulb 51·4° F.

THE SKIN-SHIRT TEMPERATURE

It is a well-known fact that there is always a layer of stagnant air between the clothing and the skin which is usually at a higher temperature and at a greater degree of saturation with moisture than the external air. The more the body perspires and blocks the pores of the clothing the greater becomes the degree of saturation of this air. In a cool climate the difference in temperature between this air immediately surrounding the body and the outer air is much more marked.

For comparison with the experiments of Hill, dry and wet bulb temperatures were taken by two thermometers which were prevented from touching the skin by being enclosed in a small wire cage. The bulb of one was covered with a woven cotton glove and was dipped in water before inserting between the skin and the shirt. The figures obtained in these experiments under various conditions are given in the tables.

It was observed that when the subjects were out of doors the skin-shirt temperatures ran roughly parallel with the air temperatures, and were several degrees above these. In the hot season the difference between the dry bulb temperatures of the skin-shirt air and the outer air was less marked than between the wet bulb temperature.

Hill has published a number of skin-shirt temperatures which he collected in England, and it is noticeable that many of his figures taken out of doors in winter with the subject at rest, are as high as those registered in North Queensland in a tropical summer (e.g., he observed wet bulb temperatures of 88° on several occasions). It must be borne in mind that the subjects of Hill's experiments were wearing heavy clothing, whereas the clothing worn here was of the lightest description. These figures thus show the influence of the clothing on the temperature of this air, and bear out the truth of Rubner's remark that a clothed man always lives in a tropical climate as far as his body is concerned.

The effect of moving air upon the skin-shirt temperature were also studied by Hill who showed that these greatly effected this temperature; on a windy day he recorded skin-shirt temperatures as low as 64° F. wet and 74° F. dry, whilst temperatures lower than these were also observed by him when the rush of air was made by cycling rapidly downhill into the wind. The effect of air movement in the experiments done in Townsville was not nearly so marked as in those quoted above.

The figures recorded in the cooler season of the year show much lower skin-shirt temperatures. A wet bulb skin-shirt temperature as low as 64·8° F. was observed on a very windy, showery day in

June, the subject at the time feeling so cold that he was shivering. Much higher temperatures were observed when the subject was in the sun; thus, on one occasion skin-shirt temperatures of 103·6° dry bulb and 99·6° wet bulb were observed, and on another 98·7° dry and 90·7° wet bulb.

THE KATATHERMOMETERS AND RATE OF COOLING

It has been recognised that the wet and dry bulb thermometers do not give a true indication of the effect of the atmosphere upon the human body. Anyone who has lived in a hot moist climate knows the immense difference in comfort between moving and still air, yet little change may be observed in the actual air temperatures under the two conditions. Since the comfort or discomfort of the body is determined by the rate at which cooling can take place, and not by the actual temperature of the surroundings, Hill has devised the katathermometers, which measure the rate of the heat loss, i.e., the cooling power of the atmosphere under the existing conditions. In the tropics when the outer temperatures are high, the evaporation of the sweat plays a much greater part in the cooling mechanism of the body than it does in a temperate climate, so that the rate of cooling of the wet bulb katathermometer is a closer representation of the actual conditions than the dry bulb instrument.

In these experiments the time taken for the dry katathermometer to fall from 110° to 100° only was generally recorded, on account of the long time taken to cool to 90°: the wet bulb was generally carried on to 90°. These times are given in the tables in seconds. It has been found convenient for comparison of the figures to express the rate of cooling over the whole ten degrees in degrees lost per minute; these figures are also given in some of the tables.

It was observed by Osborne (1916) in Melbourne, that the wet bulb katathermometer is extremely sensitive to air currents, and that successive readings outdoors, especially in dry weather, may show very considerable variations. Katathermometer observations carried out here have shown this objection to be justified, especially as regards the wet bulb instrument. If a series of readings be taken in rapid succession in still air indoors, or outdoors on a still day, fairly consistent times may be obtained, and the same is true if a steady wind be blowing. On a day, however, with the wind coming in gusts great variations may be observed. Experience in Townsville has shown how very seldom days occur in which a series of observations can be done out of doors without fairly large variations, and what would be felt as a still tropical day is often not so calm when tested by the wet katathermometer. Several observations with the wet katathermometer are given in Table II to illustrate these points.

TABLE II.

No.	Air Temperature		Wet Bulb Katathermometer		
	Dry B.	Wet B.	110°—100°	100°—90°	
			seconds	seconds	
(1)	88·1	81·7	76	152	Indoors with doors closed. 10 minutes readings.
	89·0	81·9	73	151	
	89·0	81·9	77	155	
(2)	63·3	52·0	17	20	Outdoors, cool season breeze blowing. 5 minutes readings.
	...	...	15	20	
	64·7	51·8	15	22	
	65·8	52·8	16	21	
(3)	87·1	80·2	67	128	Hot season. Outdoors, wind in gusts. 5 minutes readings.
	...	...	48	89	
	...	...	52	83	
	...	...	76	124	
(4)	74·0	66·3	39	60	Outdoors, cool season. Breezy day. 10 minutes reading.
	75·2	66·9	46	56	
	76·2	67·3	32	51	
(5)	82·4	77·2	56	104	Day felt extremely close and uncomfortable. 5 minutes readings.
	82·0	76·5	49	74	
	81·8	76·3	57	94	
	82·0	77·0	62	99	
	82·0	77·0	61	114	

Nos. 1 and 2 show that constant readings could be obtained indoors, as well as outdoors when a strong steady wind was blowing; Nos. 3 and 4 show the effects of gusts of wind, and No. 5 shows the variations over half an hour on a day that was classed to the senses as very close and uncomfortable.

On account of these variations a series of observations was made with the wet katathermometer at intervals during the whole time of each experiment, and the average of the series taken as a representation of the cooling power during the time. With the dry katathermometer the time occupied in cooling, especially in the hot season, was much longer; thus, a sudden gust of wind would not produce so noticeable an effect.

The times recorded for the katathermometers to cool, in most cases, are of course much longer than those recorded by Hill in England. Indoors, in the hot season, the average time taken for the wet bulb katathermometer to cool from 110° to 100° was 74 seconds, and for the dry bulb instrument 330 seconds, approaching in fact some of the observations recorded by Hill in an artificially heated chamber, and similar to conditions found by him in weaving sheds in England, where the wet bulb temperature was 80° F. and more.

In the outdoor experiments considerable variations were noted, the rate of cooling from 110° to 100° varying from 250 seconds dry bulb in the hot season to 42 in the cool season, and 60 seconds wet bulb down to 16 seconds in the cool season.

It is interesting to note that on one or two days in June the time of cooling of the katathermometers was quite as low as some of the times recorded by Hill in England in winter (Table V, No. 16, and Table VI, No. 12).

THE RESPIRATORY METABOLISM

The experiments carried out indoors, Tables III and IV, were all performed in the same room with doors closed, so that in the comparison between the two seasons the only differences in outer conditions were those due to atmospheric temperature. Indoors, during the hot season experiments, the air temperatures averaged 87° F. dry bulb and 80° F. wet bulb, whilst in the cool season the averages were much lower, 71° to 74° F. dry bulb and 63° to 67° wet bulb. The rate of cooling indoors, as measured by the katathermometers, did not vary to any great extent on the different days of each season, but a marked difference was observed between the average rates of cooling during the hot and cool weather. With both subjects the average quantities of oxygen consumed and carbon dioxide eliminated were greater in the hot season. Thus, in subject W. J. Y., the average oxygen consumed was 248 c.c. in the hot

	Date	Air Temp.		Skin-Shirt Temp.		Katathermometers 110°—100°				Vol. of air expired Litres per 20 min.	Analysis of expired air.		CO₂ eliminated c.c. per min.	O₂ consumed c.c. per min.	Resp. Quot.	Rect. Temp.
						Time in Secs.		Rate of cooling Degrees per min.								
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.		CO₂%	O₂%				
Hot Season	1.3.16	88·5	81·8	92·9	88·3	345	76	1·7	7·9	109	3·66	16·50	198	254	0·78	99·2
	2.3.16	87·4	80·2	91·1	84·3	288	66	2·1	9·1	103	3·47	16·80	177	223	0·79	99·4
	3.3.16	88·1	80·1	92·0	87·5	301	72	2·0	8·3	121	3·56	16·83	214	258	0·83	99·0
	4.3.16	89·5	81·9	92·0	87·5	306	69	2·0	8·7	113	3·69	16·51	205	261	0·79	99·2
	5.3.16	87·6	80·3	91·1	85·1	294	72	2.0	8·3	115	3·54	16·98	202	234	0·86	99·2
	6.3.16	87·2	80·0	92·0	83·2	274	71	2.2	8·4	108	3·49	16·74	186	236	0·79	99·1
	7.3.16	87·3	80·2	91·8	85·3	290	71	2·1	8·4	111	3·57	16·65	197	250	0·79	99·1
	20.3.16	86·5	79·2	91·5	84·2	334	75	1·8	8·0	106	3·79	16·33	199	258	0·77	99·0
	21.3.16	85·3	78·3	92·1	86·7	314	73	1·9	8·2	115	3·91	16·37	224	275	0·77	99·2
	29.3.16	84·0	75·7	89·8	80·1	313	80	1·9	7·5	103	3·80	16·59	196	231	0·85	98·8
	4.4.16	82·8	78·4	89·6	83·4	302	82	2·0	7·3	105	3·92	16·41	204	246	0·83	98·9
Cool Season 1	22.5.18	72·7	65·1	84·6	73·5	192	62	3·1	9·7	88	3·61	16·54	157	203	0·78	98·4
	23.5.18	74·5	69·8	83·9	74·2	205	62	2·9	9·7	79	3·76	16·24	147	197	0·75	98·2
	24.5.18	72·5	64·7	81·2	74·0	194	60	3·1	10·0	87	3·68	16·29	159	212	0·75	98·5
Cool Season 2	20.6.19	72·1	61·5	85·1	71·8	192	56	3·1	10·7	85	3·70	16·19	156	213	0·74	98·4
	23.6.19	69·2	61·5	82·7	74·8	173	56	3·5	10·7	87	3·92	16·10	168	220	0·76	98·2
	24.6.19	72·2	65·0	81·0	73·5	195	57	3·1	10·5	93	4·12	16·09	191	235	0·81	98·2
	25.6.19	72·6	62·2	82·7	74·0	193	54	3·1	11·1	88	3·67	16·41	161	210	0·81	98·4
	26.6.19	71·5	62·6	82·3	70·5	173	56	3·5	10·7	87	3·95	16·10	169	219	0·77	98·2
	27.6.19	73·1	68·1	83·2	75·3	188	58	3·2	10·3	82	3·83	16·26	156	202	0·78	98·0
	3.7.19	69·6	60·5	80·6	74·4	173	54	3·5	11·1	88	3·74	16·15	164	210	0·78	98·5
	4.7.19	68·2	58·1	78·5	69·3	165	53	3·6	11·3	90	3·93	16·00	175	233	0·75	98·6
	9.7.19	72·2	64·0	81·8	71·6	189	55	3·2	10·9	86	3·80	16·09	162	220	0·74	98·1
	11.7.19	69·2	64·5	79·0	71·4	226	55	2·7	10·9	96	3·83	16·31	182	231	0·79	98·7
	18.7.19	74·1	65·9	82.8	73·8	199	58	3·0	10·3	92	3·56	16·37	168	223	0·73	98·0
						AVERAGES										
Hot Season ...	—	87·0	80·0	91·0	85·0	305	73	2·0	8·2	110	...	...	200	248	0·80	...
Cool Season 1 ...	—	73·0	67·0	83·0	74·0	197	61	3·0	9·8	85	...	...	155	204	0·76	...
Cool Season 2 ...	—	71·0	63·0	82·0	73·0	191	55	3·1	10·9	89	...	...	168	219	0·77	...

season, and the average carbon dioxide eliminated was 200 c.c., whereas in the cooler weather series averages of 204 and 219 for the oxygen and 155 and 168 for the carbon dioxide were obtained. Taking, for convenience, the minimum absorption of oxygen in each series as a basis, the extreme variation observed in the hot season series was 23 per cent., and in the two cool seasons series 8 per cent. and 16 per cent. of the minimum respectively. It is noticeable further, that the total quantity of air breathed in this subject was distinctly greater with the higher external temperatures.

With the other subject, J. W. F. (Table IV), similar observations were recorded indoors, the average for the oxygen being 256 and 222 c.c., and for the carbon dioxide eliminated 217 and 183 c.c. respectively in the hotter and cooler weather.

In the experiments done out of doors the external conditions were more varied. Large variations were observed in the wet and dry bulb air temperatures in the hot season, and the cooling power of the atmosphere, as measured by the katathermometers, also showed considerable differences from day to day. Thus, with the air temperatures above 80° dry and 70° wet bulb, the extreme variations in the time that the dry bulb katathermometers took to cool from 110° to 100° were 250 and 94 seconds, and the wet bulb instrument 60 to 35 seconds, whilst in the cooler weather, with lower air temperatures, times taken were on more than one occasion as low as 45 seconds for the dry bulb and 19 seconds for the wet bulb katathermometers. In these outdoor experiments, however, it was also noticeable that the metabolism was generally higher with the higher outer temperatures.

The comparison was rendered more difficult in the outdoor experiments by the fact that on certain days in the cooler weather the subject felt decidedly cold, often sufficiently so to be shivering, and on these occasions an increased metabolism was observed (Table V, Nos. 14, 15, 16 and Table VI, Nos. 10, 11, 12). An example is No. 16 in Table V, done on a windy day in June with air temperatures of 64·3° dry bulb and 51·4° wet bulb, in which the subject was so cold as to be shivering, in spite of the fact that he was wearing a coat; the rectal temperature fell 0·8° during the period. On these days it was observed that the temperatures between the skin and shirt were much lower.

Table IV.

Subject J. W. F. Indoor Experiments.

	Date	Air Temp.		Skin-Shirt Temp.		Katathermometers 110°—100°				Vol. of air expired Litres per 20 min.	Analysis of expired air.		CO_2 eliminated c.c. per min.	O_2 consumed c.c. per min.	Resp. Quot.	Rect. Temp.
						Time in Secs.		Rate of cooling Degrees per min.								
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.		CO_2%	O_2%				
Hot Season	22.3.16	85·9	78·3	91·5	85·5	322	70	1·9	8·6	116	3·62	16·73	208	253	0·82	98·8
	23.3.16	84·8	76·1	90·0	85·3	328	69	1·8	8·6	119	3·67	16·82	217	253	0·86	99·2
	24.3.16	86·1	75·6	90·4	84·3	316	66	1·9	8·8	127	3·63	16·85	228	267	0·85	99·2
	25.3.16	85·8	75·8	90·5	84·4	322	70	1·9	8·6	116	3·58	16·89	205	241	0·85	99·0
	5.4.16	83·0	77·6	89·4	84·8	282	87	2·1	6·9	121	3·74	16·66	225	268	0·84	99·0
Cool Season	24.5.18	73·9	67·9	83·6	74·7	183	58	3·3	10·3	122	3·04	17·52	183	214	0·86	98·6
	29.5.18	75·2	69·8	86·0	76·9	195	59	3·1	10·2	111	3·34	16·99	184	228	0·81	99·0
	5.6.18	73·5	64·3	85·1	72·9	183	58	3·3	10·3	118	3·41	16·95	182	223	0·82	98·8
							Averages.									
Hot Season —	—	85·0	77·0	90·0	85·0	314	72	1·9	8·3	120	...	...	217	256	0·84	...
Cool Season —	—	74·0	67·0	85·0	75·0	187	58	3·2	10·3	117	...	...	183	222	0·83	...

TABLE V.

Subject W. J. Y. Outdoor Experiments.

No.	Date	Air Temp.		Skin-Shirt Temp.		Katathermometers 110°—100°				Vol. of air expired Litres per 20 min.	Analysis of expired air.		CO_2 eliminated c.c. per min.	O_2 consumed c.c. per min.	Resp. Quot.	Rect. Temp.	Remarks
						Time in Secs.		Rate of cooling Degrees per min.									
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.		CO_2%	O_2%					
1	7.3.16	90·3	79·5	93·3	83·7	250	45	2·4	13·3	107	3·49	16·75	186	234	0·79	99·4	Light breeze; sweating
2	8.3.16	91·1	79·8	92·7	84·2	231	45	2·6	13·3	114	3·62	16·56	205	261	0·78	99·1	Uncomfortably hot; sweating.
3	9.3.16	89·9	78·4	92·0	83·4	228	49	2·6	12·2	115	3·44	16·88	196	243	0·81	99·2	Light breeze; not sweating
4	14.3.16	87·1	78·6	90·7	83·6	189	42	3·2	14·3	112	3·56	16·73	198	245	0·81	98·8	Breeze fairly strong; sun obscured by clouds.
5	15.3.16	84·2	76·8	90·3	89·1	119	44	5·0	13·6	105	3·56	16·63	186	237	0·78	99·2	Gusty winds, rain at end; D.B. Temp. falling 5°.
6	16.3.16	85·0	76·1	90·3	83·7	244	60	2·5	10·0	103	3·70	16·56	190	236	0·80	99·0	Very close and overcast.
7	20.3.16	86·4	76·5	90·6	81·8	141	40	4·2	15·0	108	3·71	16·57	199	245	0·80	99·3	Breezy day.
8	21.3.16	86·7	76·8	90·8	83·2	162	40	3·7	15·0	125	3·77	16·27	201	264	0·76	99·0	Light Breeze
9	27.3.16	85·0	74·0	89·1	78·7	157	43	3·8	14·0	105	3·71	16·53	196	241	0·80	99·3	Light breeze.
10	29.3.16	82·2	72·5	86·6	74·9	123	38	4·9	15·8	111	3·78	16·77	209	237	0·88	99·0	Breezy day.
11	4.4.16	83·2	75·0	88·5	78·9	166	48	3·6	12·5	92	3·83	16·34	174	216	0·81	98·9	Rather close.
12	6.4.16	86·4	69·0	89·8	74·5	172	39	3·5	15·4	96	3·89	16·30	186	232	0·80	99·4	Fair breeze. Note lower wet bulb.
13	17·4·16	82.4	69·8	87·8	74·4	162	30	3·7	20·0	96	3·81	16·28	182	235	0·77	98·7	Strong breeze.
14	24.6.16	71·9	56·7	80·6	66·6	119	27	5·0	22·2	98	4·01	16·17	194	243	0·80	99·4	Faint breeze; feeling distinctly cold.
15	29.6.16	62·8	58·4	73·3	65·4	73	36	8·2	16·7	108	3·86	16·46	206	250	0·82	98·8	Breezy; Rectal Temp. fell to 97·8; shivering.
16	30.6.16	64·3	51·4	77·0	63·1	44	19	13·6	31·4	119	3·89	16·44	230	278	0·83	98·6	Breezy; Rectal Temp. fell to 97·8; shivering.
17	30.3.17	83·8	75·0	87·8	78·9	155	44	3·9	13·6	98	3·46	16·64	167	220	0·76	98·8	Light breeze.
18	13.4.17	84·0	73·0	88·7	76·6	230	51	2·6	11·7	99	3·57	16·55	174	211	0·82	98·4	Close
19	24.4.17	84·2	71·7	86·4	74·8	174	42	3·4	14·3	98	3·51	16·87	168	204	0·82	98·9	Moderate breeze.
20	22.5.18	75·1	62·9	81·0	69·1	120	34	5·0	17·6	120	3·49	16·66	208	269	0·77	98·0	Strong breeze; feeling cold towards end.
21	28.5.18	75·6	65·3	81·0	70·2	88	28	6·8	21·4	92	3·50	16·72	150	204	0·79	98·2	Strong breeze.
22	...	73·0	59·0	78·0	67·0	85	27	7·1	22·2	96	...	...	170	215	0·79	...	Average of 11 observations in cool season. Table VII.
23	25.2.16	87·0	79·9	90·9	84·0	123	40	...	...	107	3·66	16·16	191	275	0·72	98·9	In shade.
,,	,,	...	...	103·6	99·6	...	53	...	...	119	3·38	16·85	202	252	0·80	99·3	Sitting in sun for 30 min.

Another question investigated was whether the cooling power of the atmosphere observed during the hot season, as measured by the katathermometer, influenced the metabolism in any way. The figures did not show any definite changes in the metabolism with rate of cooling. In the cooler weather a high rate of metabolism was observed in a few cases on days which had a high rate of cooling, but it was noticeable that this occurred only when the subject felt cold.

No such marked changes were observed as those obtained by Hill in England, who found in outdoor experiments that the greatest rate of metabolism coincided with the greatest rate of cooling.

Observations were made on the effects of increasing the rate of cooling by performing experiments, first indoors and then outdoors, upon the same day, in the same manner as done by Hill (1912).

The subject in each case reclined motionless for at least 40 minutes under each set of conditions before breathing into the meter. Tables VII and VIII give the results of a number of such experiments, the indoor experiments being carried out in a closed room. In the hot season experiments no increase in the metabolism was observed out of doors, although the cooling power was considerably higher outside. The difference in comfort indoors in a closed room and outdoors in the breeze was very marked. Moving air was thus without any definite effect when the outer temperatures were high (over 80° dry bulb and 70° wet bulb), showing that the increased rate of cooling was insufficient to reduce the body temperature during the experiment. With the lower external temperatures observed in the cool season differences were observed. The pulmonary ventilation was generally greater out of doors, and in certain instances there was a decided increase in carbon dioxide eliminated and oxygen consumed. This occurred on windy days when the cooling power of the atmosphere was high and when the subject felt cold: on these days the rate of cooling was often sufficient to reduce the rectal temperature. On the whole, however, no marked increase in the oxygen consumed was observed, and it is noteworthy that the averages for the eleven observations on W. J. Y. showed no increase out of doors excepting that the total volume expired was greater. In several experiments the increased ventila-

Table VI.

Subject J. W. F. Outdoor Experiments.

No.	Date	Air Temp.		Skin-Shirt Temp.		Katathermometers 110°—100° Time in Secs.		Katathermometers 110°—100° Rate of cooling Degrees per min.		Vol. of air expired Litres per 20 min.	Analysis of expired air.		CO_2 eliminated c.c. per min.	O_2 consumed c.c. per min.	Resp. Quot.	Rect. Temp.	Remarks.
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.		CO_2%	O_2%					
1	13.3.16	89·0	77·3	92·5	85·7	194	38	3·1	15·8	132	3·47	17·10	228	261	0·87	99·5	Good breeze.
2	14.3.16	87·6	78·2	89·5	84·9	207	49	2·9	12·2	143	3·74	16·90	266	295	0·90	99·2	Slight breeze.
3	15.3.16	86·5	78·2	91·3	85·3	164	50	3·7	12·0	112	3·52	16·92	195	232	0·84	99·2	Wind in gusts; sweating.
4	16.3.16	82·6	75·6	89·8	85·7	236	51	2·5	11·8	115	3·80	16·40	217	273	0·80	99·1	Still day.
5	22.3.16	86·8	76·7	93·1	83·9	161	50	3·7	12·0	122	3·61	16·91	219	253	0·86	98·8	Still day.
6	24.3.16	86·4	72·3	89·7	78·3	170	39	3·5	15·4	127	3·67	16·85	231	267	0·87	99·6	Good breeze.
7	5.4.16	83·7	75·9	88·9	79·0	94	35	6·4	17·1	113	3·76	16·73	211	245	0·86	98·4	
8	6.4.16	84·7	66·5	88·0	74·4	129	30	4·6	20·0	111	3·99	16·53	220	251	0·88	99·5	Note lower wet bulb.
9	7.4.16	84·3	69·7	86·8	76·8	134	31	4·5	19·4	110	4·09	16·30	223	263	0·85	99·4	Strong wind.
10	25.6.16	74·5	65·8	84·4	77·8	127	39	4·7	15·4	119	4·07	16·41	240	277	0·87	...	Still day.
11	29.6.16	64·0	59·7	78·9	72·7	93	40	6·4	15·0	109	4·03	16·33	218	260	0·84	99·3	Raining; breezy; feeling cold.
12	30.6.16	64·0	51·2	77·2	64·8	42	16	14·3	17·5	116	4·03	16·51	231	262	0·88	99·5	Strong wind; feeling cold; Rectal temp. fell from 99·5 to 99·0.
13	11.4.17	83·2	73·1	88·1	81·0	191	49	3·1	12·2	136	3·37	17·26	228	256	0·89	99·1	
14	17.4.17	85·4	73·9	88·4	79·4	205	52	2·9	11·5	131	3·35	17·18	218	254	0·86	99·7	
15	24.5.18	73·3	65·6	79·8	70·7	76	31	7·9	19·3	138	2·94	17·76	201	224	0·90	98·6	
16	29.5.18	75·0	68·0	83·7	72·4	79	26	7·6	23·1	112	3·45	16·88	191	236	0·81	99·0	

No.	Date	Air Temp.		Skin-Shirt Temp.		110°—100°		110—90°		Vol. of air expired Litres per 20 min.	Analysis of expired air		CO₂ eliminated c.c. per min.	O₂ consumed c.c. per min.	Resp. Quot.	Remarks.	
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Drv B.	Wet B.		CO_2%	O_2%					
1	20.3.16	86·5	79·2	91·5	84·2	334	75	1259	230	106	3·79	16·33	199	258	0·77	In	
		86·9	76·6	90·6	81·8	141	40	439	106	108	3·71	16·57	199	245	0·80	Out	
2	21.3.16	85·3	78·3	92·1	86·7	314	73	1050	217	115	3·91	16·37	224	275	0·77	In	
		86·7	76·8	90·8	83·2	162	40	642	110	108	3·77	16·27	201	264	0·76	Out	
3	29.3.16	84·0	75·7	89·8	80·1	313	80	1028	212	103	3·80	16·59	196	231	0·85	In	
		82·2	72·5	86·6	74·9	123	38	300	82	112	3·78	16·77	209	237	0·88	Out	
4	4.4.16	82·8	78·4	89·6	83·4	302	82	927	234	105	3·92	16·41	204	246	0·83	In	
		83·2	75·0	85·6	78·9	166	48	496	121	92	3·83	16·34	174	216	0·81	Out	
5	22.5.18	72·7	65·1	84·6	73·5	192	62	484	156	88	3·61	16·54	157	203	0·78	In	Cooler season.
		75·1	62·9	81·0	69·1	120	34	283	73	120	3·49	16·66	208	269	0·77	Out	Feeling cold; strong breeze; Rectal temp. fell to 98°.
6	28.5.18	74·5	69·8	83·9	74·2	205	62	514	160	79	3·76	16·24	147	197	0·75	In	
		75·6	65·3	81·0	70·2	88	28	216	67	92	3·50	16·72	157	204	0·79	Out	
7	20.6.19	72·1	61·5	85·1	71·8	192	56	480	136	85	3·70	16·19	156	213	0·74	In	
		72·2	54·2	77·2	61·2	87	30	207	63	92	3·39	16·75	154	202	0·76	Out	
8	23.6.19	69·2	61·5	82·7	74·8	173	56	426	135	87	3·92	16·10	168	220	0·76	In	
		71·4	60·0	81·4	73·6	127	37	306	87	88	3·57	16·69	158	196	0·80	Out	Very little breeze.
9	24.6.19	72·2	65·0	81·0	73·5	195	57	485	141	93	4·12	16·09	191	235	0·81	In	
		78·4	64·3	83·2	72·6	109	26	298	59	90	3·61	16·47	161	211	0·76	Out	Gusty breeze.
10	25.6.19	72·6	62·2	82·7	74·0	193	54	494	133	88	3·67	16·41	161	210	0·81	In	
		72·4	55·5	76·3	65·4	63	19	165	46	106	3·44	16·89	181	223	0·77	Out	Good breeze; feeling cold.
11	26.6.19	71·5	62·6	82·3	70·5	173	56	450	137	87	3·95	16·10	169	219	0·77	In	
		72·5	59·3	79·2	65·8	73	28	224	60	94	3·56	16·66	166	210	0·79	Out	Very slight wind.
12	27.6.19	73·1	68·1	83·2	75·3	188	58	479	150	82	3·83	16·26	156	202	0·78	In	
		73·4	65·3	77·0	67·3	68	26	182	59	97	3·49	16·90	167	202	0·83	Out	Moderate wind.
13	3.7.19	69·6	60·5	80·6	74·4	173	54	427	129	88	3·74	16·15	164	210	0·78	In	
		70·5	59·0	79·3	67·8	111	33	313	78	93	3·87	16·45	179	216	0·83	Out	Wind in gusts.
14	4.7.19	68·2	58·1	78·5	69·3	165	53	402	127	90	3·93	16·00	175	233	0·75	In	
		68·0	51·3	76·1	60·5	55	24	154	54	103	3·62	16·67	184	228	0·81	Out	Good breeze.
15	9.7.19	72·2	64·0	81·8	71·6	189	55	482	135	86	3·80	16·09	162	220	0·74	In	
		72·9	59·5	75·8	64·7	97	26	263	57	102	3·54	16·61	179	232	0·77	Out	Wind in gusts; uneven cooling.
16	11.7.19	69·2	64·5	79·0	71·4	226	55	478	135	96	3·83	16·31	182	231	0·79	In	
		71·2	61·3	78·7	70·4	67	24	185	58	92	3·73	16·38	171	219	0·78	Out	
17	18.7.19	74·1	65·9	82·8	73·8	199	58	518	149	92	3·56	16·37	168	223	0·73	In	
		76·4	62·0	80·3	73·5	74	24	203	57	99	3·54	16·53	174	229	0·76	Out	Very strong wind.
								Average Results.									
		85·0	78·0	91·0	84·0	316	78	1066	223	107	...	...	206	252	0·80	In	4 days in hot season.
		85·0	75·0	88·0	81·0	148	41	469	105	105	...	...	196	240	0·81	Out	Nos. 1—4.
		87·0	80·0	91·0	85·0	305	73	...	...	110	...	...	200	248	0·80	All indoor experiments hot season 11 observations.	
		87·0	77·0	90·0	82·0	183	45	...	...	109	...	...	195	242	0·80	All outdoor experiments same period 11 observations.	
		74·0	67·0	84·0	74·0	198	62	499	158	84	...	...	153	200	0·76	In	2 days in cool season, 1918
		75·0	64·0	81·0	70·0	104	31	249	70	106	...	...	184	236	0·78	Out	Nos. 5 and 6.
		71·0	63·0	82·0	73·0	191	55	468	137	88	...	...	168	219	0·77	In	11 days in cool season, 1919.
		73·0	59·0	78·0	67·0	85	27	228	62	96	...	...	170	215	0·79	Out	Nos. 7—17.

TABLE VIII.

Subject J. W. F. Effects of Wind. Experiments done Indoors and Outdoors.

No.	Date	Air Temp.		Skin-Shirt Temp.		Katathermometers, Time in Secs.				Vol. of expired air Litres per 20 min.	Analysis of expired air		CO_2 eliminated c.c. per min.	O_2 consumed c.c. per min.	Resp. Quot.		Remarks.
						110°—100°		110°—90°									
		Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.	Dry B.	Wet B.		CO_2 %	O_2 %					
1	22.3.16	85·9	78·3	91·5	85·5	322	70	1212	206	116	3·62	16·73	208	253	0·82	In	
		86·8	76·7	93·1	83·9	161	50	...	121	122	3·61	16·91	219	253	0·86	Out	
2	24.3.16	86·1	75·6	90·4	84·3	316	66	...	202	127	3·63	16·85	228	267	0·85	In	
		86·4	72·3	89·7	78·3	170	39	542	97	127	3·67	16·85	231	267	0·87	Out	Good breeze blowing.
3	5.4.16	83·0	77·6	89·4	84·8	282	87	...	234	121	3·74	16·66	225	268	0·84	In	
		83·7	75·9	88·9	79·0	94	35	912	91	113	3·76	16·73	211	245	0·86	Out	
4	24.5.18	73·9	67·9	83·6	74·7	183	58	469	146	122	3·02	17·52	183	214	0·85	In	
		73·3	65·6	79·8	70·7	76	31	217	71	138	2·94	17·76	201	224	0·90	Out	
5	29.5.18	75·2	69·8	86·0	76·9	195	59	498	151	111	3·34	16·99	184	228	0·80	In	
		76·9	68·0	83·7	72·4	79	26	209	64	112	3·45	16·88	191	236	0·81	Out	Not much wind.
6	5.6.18	73·5	64·3	85·1	72·9	183	58	458	135	118	3·41	16·95	182	223	0·82	In	Resp. rate 13·5.
		80·5	61·8	86·2	71·6	112	24	285	58	127	3·28	16·93	205	266	0·77	Out	Resp. rate 14·5, feeling cold.
								AVERAGE RESULTS.									
		85·0	77·0	90·0	85·0	311	76	...	214	121	...	...	220	263	0·84	In	Hot season experiment.
		86·0	76·0	91·0	80·0	175	45	...	136	121	...	...	220	255	0·86	Out	Nos. 1—3.
		74·0	67·0	85·0	75·0	187	58	475	144	116	...	...	187	226	0·82	In	Cool season.
		77·0	65·0	83·0	72·0	89	27	237	64	127	...	...	203	247	0·83	Out	Nos. 4—6.

tion may have caused a washing out of carbonic acid from the tissues, since on some occasions the respiratory quotient was slightly higher out of doors. The difference in the rate of cooling indoors and outdoors was on no occasion so great as on those days recorded by Hill as 'bracing,' when he observed a very large increase in the metabolism out of doors. The rate of cooling due to air movement must therefore be increased beyond a certain limit in order to stimulate the body to an increase in respiratory metabolism. These results agree in the main with Wolpert's observations that moving air has very little effect upon the carbon dioxide output between 78° and 95° F., but below this it produces an increase.

One experiment was carried out under similar conditions to those investigated by Harvey Sutton (1908) with high temperatures and so high a saturation of moisture as to prevent all cooling through evaporation of sweat. This was done in a small chamber heated artificially. Before entering the chamber the subject (W. J. Y.) breathed in the usual manner for five minutes into the meter, and a sample was taken for analysis. After thirty minutes in the hot room, a second breathing into the meter was performed, and again after seventy minutes. The figures obtained are seen in Table IX.

TABLE IX.

ir Temp.		Wet-bulb Kata. 110°-100°	Rectal Temp.	Pulse	Vol. expired Litres per min.	CO$_2$ c.c. per min.	O$_2$ c.c. per min.	Resp. Quot.	
.B.	W.B.								
·6	69·5	63	99·5	76	6·4	198	216	0·91	Before entering.
·8	93·0	...	100·5	112	8·6	294	327	0·90	After 30 mins. in hot room.
·3	96·0	241	103·0	168	9·7	311	375	0·83	After 70 mins.

The subject was naked and was perspiring profusely during the experiment, losing 650 grms. in weight, practically all of which would be due to sweat. The result was similar to those recorded by Sutton, the rectal temperature rose, slowly at first, more rapidly later, and the metabolism was increased. It was not observed, however, that the respiratory quotient rose towards unity as described by Sutton. The last breathing was extremely trying, the mouthpiece proving somewhat uncomfortable under the existing conditions, and was accompanied by a sensation of suffocation, which may have affected the breathing in this case.

It is interesting to note here some observations which were made during exercise. The effort consisted in walking on the flat for fifteen minutes, at the rate of three miles per hour, and the meter was carried on a wooden stand strapped to the shoulders like a knapsack, the total weight carried being approximately 13 kilograms. These experiments are detailed in Table X. The temperatures given are the shade temperatures at the time; the walking, however, was performed in the sun. The calories, corresponding to the oxygen consumed, are calculated from the data given by Cathcart (1915).

TABLE X.

	Shade Temp.		Rectal Temp.	Vol. expired Litres per min.	CO_2 c.c. per min.	O_2 c.c. per min.	Resp. Quot.	Resp. Rate	Calories per min.	
	Dry B.	Wet B.								
W. J. Y. (1)	83·8	75·0	98·8	4·9	167	220	0·76	12¼	1·06	Rest.
			99·6	19·4	781	959	0·81	19½	4·62	Exercise
(2)	84·0	73·0	98·4	4·9	174	211	0·82	12½	1·02	Rest.
			100·2	20·7	901	1119	0·81	26½	5·40	Exercise
J. W. F. (3)	83·2	73·1	99·1	6·8	228	256	0·89	14¾	1·26	Rest.
			99·8	17·4	698	836	0·83	20¼	4·04	Exercise
(4)	83·4	73·9	99·7	6·6	218	254	0·86	16¼	1·24	Rest.
			100·0	20·2	1007	1260	0·80	20½	6·05	Exercise

As already pointed out, in the tropics the loss of heat from the body takes place to a greater extent by evaporation of the perspiration than it does in a temperate climate. It is of interest, therefore, to calculate the amount of water which would have to be evaporated to neutralise the heat produced in these experiments, assuming for the time that all heat was lost in this way.

The largest production of heat with subject W. J. Y. amounted to 5·4 calories per minute; 1 litre of water evaporated at 98·6°

requires 582 calories, so that to neutralise this amount of heat would require the evaporation of about 9 c.c. per minute or 540 c.c. per hour.

With the second subject (J. W. F.) in Experiment No. 4, 6·5 calories were produced, and the evaporation of 10·4 c.c. of water per minute would be required to neutralise this heat, or 626 c.c. per hour.

In another research (1919) the loss in body weight of the same two subjects during walking exercise was measured, the subjects being weighed in their clothing, so that the loss in weight practically represents the perspiration evaporated. The first subject (W. J. Y.), in walking on a hot day (D. B. 87·8°, W. B. 79·7°) for sixty minutes at about three to three and a half miles per hour, lost 740 grms. in weight, and the second subject (J. W. F.), walking the same distance in seventy-six minutes, lost 900 grms. or about 710 grms. per hour.

It is thus seen that even with a high moist temperature sufficient evaporation can take place to neutralise the heat produced by such exercise as that performed, even if this evaporation were the only source of heat loss. These experiments, however, caused profuse perspiration, and it shows how necessary it is in the tropics to supply the body with sufficient water (cf. Hunt (1912)).

DISCUSSION

The ventilation of the lungs, carbon dioxide expired and oxygen consumed, were greater in the summer than in the cooler weather, excepting on a few days when the subjects were cooling sufficiently rapidly to feel cold and to produce shivering, on which occasions larger metabolism was observed.

The results agree, therefore, with those found by Osborne (1912), who found that the pulmonary ventilation and the carbon dioxide produced varied directly with the external temperatures, and who pointed out also that the rate of respiration is noticeably higher with higher external temperatures (over 100° F.).

An increased rate of respiration in the tropics has been noticed by other observers; thus Chamberlain (1911), as the result of extended observations on six hundred and eight American soldiers stationed in the Philippine Islands, found an average respiration rate of 19·3 per minute, as against 17 to 18 per minute in temperate climates. An increased rate of respiration would in itself cause a certain small increase in the carbon dioxide produced.

With one of the subjects (W. J. Y.) the rectal temperatures in the cool weather were in most cases lower than in the summer, which would account for a certain difference in the metabolism; with the other subject, however, this was not the case, the rectal temperature did not show any marked variation in the two seasons, being generally about 99° in all the experiments. Osborne also states that he was unable to observe any rise in rectal temperature whilst at rest which would have caused the increase observed in the metabolism.

A discussion of the various conditions which may affect the basal metabolism, i.e., the metabolism with complete muscular rest and in the post-absorptive condition, has been published by Benedict (1915), in which he sums up the results of the large number of experiments which have been carried out in the Nutrition Laboratory of the Carnegie Institute, Washington. These experiments have been made on a large variety of individuals, and have extended over a number of years. He pointed out how numerous the factors are which may affect the basal metabolism. Besides those more obvious factors directly connected with the mass of the organism, such as body weight, body surface, muscular development, etc., there are others which, though less obvious, have a marked effect. He has noted considerable changes (as much as 30 per cent.) from day to day in the oxygen absorption of normal individuals, and small changes in the course of twenty-four hours even in fasting subjects, which changes could not be attributed to changes in the active mass of the body.

Benedict and Cathcart (1913), experimenting with a professional athlete, found that after a prolonged period of severe work the metabolism remained high, although gradually decreasing, long after the external evidence of muscular activity had ceased. They further found that the metabolism of this individual, determined from day to day, showed variations which in some cases might be traced to conditions existing prior to the experiment; for instance, when he chose a rough road on his way to the laboratory the extra exertion affected the subsequent determination, and the same was true in the winter, when his walk was impeded by slippery roads.

Benedict concludes, therefore, that besides the active mass of the organism, 'the stimulus to cellular activity' existing at the time the measurement of the metabolism is made, is an important factor in determining the metabolism observed.

The metabolism at any time is thus determined not only by the conditions which obtain at the time of the actual experiment, but also by the conditions which have gone before, the results of which on the cellular activity of the organism have not had time to disappear.

The foregoing observations suggest an explanation at any rate for part of the increased metabolism found in the summer in these experiments. In a tropical summer with a hot moist atmosphere, when the least exertion is accompanied by profuse sweating, a very slight amount of muscular work will cause an increase in the body temperature and a corresponding increase in the metabolic activity. The increased activity produced by the exertion of dressing and walking to the laboratory would persist, and would not be materially reduced by the subsequent rest, before and during the actual measurement. In the summer here, it has frequently been noted how rapidly the body temperature rises with exercise and falls again only very slowly when the exercise has ceased. It was frequently observed that the subject was perspiring freely during the experiments. In the cooler season the effects of the earlier exertion would not be so great, and the greater cooling power of the atmosphere would further cause the resting period to modify the activity to a greater extent. The body temperature during the hot weather seldom changed very much during the actual experiment, whilst in the cooler season in the outdoor experiments it often showed a decided fall. The amount of actual exertion before the experiments began was roughly the same every day, yet the body temperature of one subject was usually greater in the hot weather.

One might thus expect to find the metabolism working at a slightly higher level in the very hot weather. It may be noted here that very cold weather might possibly produce a similar effect, since the increased muscular activity produced by the cold might also persist for some time.

That the metabolism was not wholly influenced by the immediate conditions is also seen by the fact that during the winter the rate of cooling of the katathermometers inside with doors closed was of the same order as that frequently found out of doors in the summer, although the oxygen consumed was lower in the former experiment.

The fact that the level of metabolism is affected by the general conditions under which the subject is living, and not only by the immediate experimental surroundings, has been entirely overlooked in experiments of comparative short duration, in which tropical conditions have been produced artificially, and it shows how these can never replace observations carried out under natural conditions upon subjects living continuously under these conditions.

SUMMARY

During the hot season of the year a greater metabolism was observed than in the cooler season, excepting on certain days in the latter, when the rate of cooling was sufficiently great to cause the subject to shiver. This greater metabolism is attributed to the effects of the ordinary activities of everyday life which had preceded the actual experiment, which in the hot moist weather produce a greater increase in body temperature, and consequently in the metabolism, than in the cool season. These effects also are reduced much more slowly during the hot season, when the cooling power of the atmosphere is low, than during the cool weather when the cooling power is much greater. The effects of such conditions prior to the actual measurement have thus a larger influence on the level of metabolism in the hot season.

With tropical heat the metabolism is at a high level on account of the increase in body temperature produced by even slight exertion, and which decreases only very gradually after the exertion has ceased. Cold may also increase the metabolism but by producing shivering and so increasing the muscular activity.

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A NOTE ON HYMENOLEPIS NANA IN NORTH QUEENSLAND.

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For a considerable time the eggs of a species of cestode have been recognized in the fæces of a relatively large number of the inhabitants of North Queensland. This fact has been emphasized since the inauguration of the Hookworm Campaign, with the attendant large number of examinations of centrifugalized stools.

The following figures are given as an indication of the incidence of infection:

	No. Examined.	No. Infected.	%
Waite (1918)	14,577	51	0.35
Half-yearly Report, Australian Institute of Tropical Medicine, July 1 to December 31, 1918	2,420	27	1.1
Townsville Orphanage, October 15, 1919	82	3	3.6
Townsville Orphanage, April 28, 1920	72	13	18.0

It is at once apparent that these results do not coincide, those from the Institute being much higher. This is probably because the last three figures all refer to children and it is a well known fact that young people are more liable to helminth infections than adults. The figures given by Waite (1918) are the result of the examination of the general population and thus include more adults than children. They are probably lower on this account.

The two results referring to the Orphanage should not be taken as any indication of the prevalence of the infection, as they are obviously too high; they are only included to show the danger of drawing conclusions from a small number of cases.

The worm itself has now been recovered from human beings and has been identified as *Hymenolepis nana* (v. Sieb.) after the description by Blanchard (1891). It has previously been reported in many other parts of the world since its discovery by Bilharz in Cairo in 1851, but this is the first time its presence has been recorded in human beings in Australia. H. Johnston (1918) reported it in rats in Sydney in

1910, which is the first mention of it in Australia, and Waite (1918) found the eggs in human fæces for the first time, but makes no mention of finding and identifying the worm.

As the eggs are liable to be encountered at any time, the following brief description may be a help in their identification:

They have a thick shell and are globular or oval in shape. They measure 30 μ to 37 μ in diameter when round, but when oval they may be as much as 50 μ to 55 μ long. The oncosphere is only 16 μ to 19 μ in diameter and is surrounded by two coverings separated by a clear space. Within it the six hooks can usually be made out.

Except in heavy infections the eggs are not easily found, it often being necessary to centrifugalize and examine several preparations before they are discovered.

In the fresh stool the worms appear as minute whitish threads, broader at one end than the other. They are only from 8 mm. to 15 mm. long, more rarely 20 mm.. It is exceptional for a complete worm to be found, because they are usually broken into fragments.

Under a low power of the microscope, or even a powerful hand lens, the head is seen to be globular and about twice the diameter of the neck, which is relatively long. The head is furnished with four relatively deep suckers and a thick rostellum at the anterior end, armed with 24 to 28 or 30 hooks. It is usually retracted within a deep fossa and is consequently not readily made out. The proglottides are always broader than long and number 140 to 170.

Many symptoms are attributed to infection with this worm, as may be seen by the frequent references in the literature. But these should be accepted with caution, as they are in no way characteristic and, as a rule, only one or two cases are reported at a time, which is not sufficient material on which to base a definite and extensive symptomatology.

The symptoms referred to are usually those of gastro-intestinal derangement, with sometimes the various nervous signs common in children in these conditions. A full description is given by Lütz (1894).

In practice, in Australia, at all events up to the present time, no cases with symptoms referable to

H. nana infection alone have been observed. As an illustration, the following case is worthy of note.

A child of ten was recently treated for the condition. She was apparently in perfect health, the presence of the worm only being accidentally discovered during an examination for *Anchylostoma duodenale*, but as the eggs were in large numbers, it was decided to treat her. After a single treatment with *ext. filic. maris*, over 1,000 worms were recovered from her stools. This clearly proved that a heavy infection can exist without causing apparent trouble.

Further, Breinl (unpublished) has noticed among a number of Italians in North Queensland with mixed infections of *A. duodenale* and *H. nana*; several of them complained of gastric pain and discomfort. It was thought that the symptoms may have been due to one or other of the above worms. But when they were quite cured of both helminth infections, the symptoms persisted, thus proving that this was not the case.

Diagnosis of the condition can, therefore, only be made by finding the eggs in the stools (*vide supra*).

Treatment is the same as in any other tapeworm infection and at the Australian Tropical Institute extract of *filix mas* has been found the most efficient vermifuge. But the following precaution is necessary to effect a cure, *viz.*, a second treatment should follow the first at an interval of about a fortnight.

The reason for this is that it is thought *H. nana*, unlike most other cestodes, is able to develope to the adult stage in the original host without intervention of an intermediary.

If this is assumed to be the case, the rationale of the double treatment is clear, because the first treatment destroys the adult worms in the gut, but does not affect the larval forms or eggs, which then go on to full development. The stage up to maturity takes about fourteen days and so the second treatment destroys these freshly-developed worms before they begin to deposit eggs and thus continue the infection.

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HUMAN INTESTINAL PROTOZOA IN NORTH QUEENSLAND

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This investigation was undertaken with the object of ascertaining if carriers of *Entamoeba histolytica* exist among the healthy population of North Queensland, as in other parts of the world. This has been shown in England by Yorke and others (1917), and by Matthews and Smith (1919), and in Egypt by Wenyon and O'Connor (1917).

In the present series the number of people examined is five hundred, and the specimens were obtained from among a number of about one thousand five hundred, which were collected by members of the "Hookworm Campaign" staff, during their investigation of that disease. With the exception of seventy-one stools from the Townsville Orphanage, they were chosen quite at random. They include all ages of the community, from 1 year to 80 years of age, and embrace a wide area of country to the North and West of Townsville, within a radius of seventy miles of the town. All the houses are small, and built of wood or galvanized iron, and are not crowded together, in many cases miles separating them. The conservancy system is pans, and the privies are not fly-proof.

From their manner of collection, the specimens were at least three, and perhaps as much as fourteen, days old before being examined, therefore no vegetative forms of the various organisms were seen, but only their cysts. And for the same reason only one examination of each case was possible. This point should be borne in mind throughout the perusal of the paper, because it has been shown by Carter and others (1917) that only about one quarter of the total *Entamoeba histolytica* infections are revealed at the first examination, and similarly one-third of the *Entamoeba coli*, and one-half of the *Lamblia intestinalis* infections only are found.

The following protozoal cysts were seen, viz.:—*Entamoeba histolytica* (Schaudinn), *Entamoeba coli* (Losch), *Lamblia* (*Giardia*) *intestinalis* (Lambl), *Tetramitus* (*Chilomastix*) *mesnili* (Wenyon). Other cysts of a vegetable nature were encountered, which are mentioned at the end of the paper.

General results. The total figures are given in Table I, and call for no special comment.

Table I.

Type of infection	No. of stools examined	No. infected	Percentage
E. histolytica	500	23	4·6
E. coli	500	134	26.4
L. intestinalis	500	59	11·8
T. mesnili	500	11	2·2
‘ ? *cyst*’	500	9	1·8

Mixed infections occurred as follows:—

E. histolytica, *E. coli*, and *L. intestinalis*, five times.

E. histolytica and *E. coli*, five times.

E. coli and *L. intestinalis*, sixteen times.

E. coli and ‘ ? *cyst*,’ three times.

E. coli and *T. mesnili*, once.

For purposes of comparison, Table II has been compiled from a paper by Carter and others (1917), with the addition of the figures given in a series of examinations by Matthews and Smith (1919), and those of the present paper.

TABLE II.

		Present series	Matthews and Smith (1919)	Carter and others (1917)	Wenyon (1915)	Dobell (1916)	Jepps (1916)	Matthews and Smith (1917)
		1	2	3	4	5	6	7
No. examined	Dys. ...	...	...	910	556	90	153	...
	Non-dys. ...	500	450	...	...	110	204	250
Total examined ...		500	450	910	556	200	426	250
E. bistolytica ...		4·6	1·5	10·3	10·8	11·0	7·7	8·0
E. coli		26·8	6·7	25·4	39·0	40·9	25·8	19·2
L. intestinalis		11·8	6·0	18·6	16·0	19·5	19·0	8·0
T. intestinalis		...	...	1·2	1·6	2·4	...	1·7
T. mesnili		2·2	1·5	2·7	0·5	7·8	...	2·0

All the figures in the above table are in percentages. It must be borne in mind that columns 1 and 2 give the results of a single examination, and the remaining columns are the aggregate of repeated examinations of each case.

The objection may be raised that some of the figures refer to dysenteric, and others to non-dysenteric cases. But Wenyon and O'Connor (1917) have shown that there is very little difference between the two classes of case, as far as percentage of carriers is concerned. This fact is well sustained in the table given above.

It is obvious, allowing for the single examination, that the igures in the present series are high, especially in regard to *E. histolytica*, *E. coli*, and *L. intestinalis*. But when compared with those of a series of examinations by Matthews and Smith 1919), in which they made one examination only, of a number of non-dysenteric cases, it is seen that they are well within the bounds of the figures for England.

This is shown in Table III, in which all the figures are in percentages, and are the result of a single examination of healthy people in every case.

Table III.

	No. examined	*E. histolytica*	*E. coli*	*L. intestinalis*	*T. mesnili*
Present series	500	4·6	26·8	11·8	2·2
Batch 1	263	3·0	12·1	4·5	...
Batch 2	241	6·6	23·2	7·5	1 case
Batch 3	230	3·9	14·8	6·1	...
Batch 4	98	6·1	21·4	8·2	...
Batch 5	84	8·2	22·4	11·8	1 case
Batch 6	104	5·8	17·4	6·7	...
Batch 7	78	12·8	23·1	10·2	...

Age incidence. The effect of age on the incidence of infection is shown in Table IV. It is in agreement with the findings of Matthews and Smith (1919), and supports the tentative view expressed by them in this connexion, that the proportion of young people infected is higher than that of adults. The present investigation covers a much wider range of ages than that of the above observers, as it embraces people from 1 year to 80 years. Nevertheless, it is open to the objection, that the numbers in the various age-groups are somewhat small, and, consequently, do not give quite accurate results, which would be obtained if a higher number were examined. This is especially noticeable in the Ophanage group 1 to 5 years, with only nine cases, and three infections by *E. coli*, thus giving a percentage of 33·3 per cent., which is obviously much too high. The fact of the relatively high incidence of *L. intestinalis* among children is well shown. This is also pointed out by the above workers.

In this, and all subsequent tables, *T. mesnili* and '?*cyst*' are not shown, because the actual number of these infections is too small for such comparison.

TABLE IV.

(PEOPLE IN PRIVATE HOUSES)

Age group in years	No. examined	Percentage infected		
		E. histolytica	*E. coli*	*L. intestinalis*
1-5	48	4·2	4·2	22·9
6-10	55	5·5	12·7	23·6
11-15	41	9·75	41·5	22·0
16-20	39	5·1	23·1	10·2
21-30	72	6·9	29·2	4·2
31-40	57	1·75	26·3	8·8
41-80	117	1·7	23·9	5·1
(ORPHANAGE CHILDREN)				
1-5	9	0·0	33·3	11·1
6-10	42	4·8	50·0	14·3
11-15	200	10·0	55·0	20·0

In the above table it will be noted that the Orphanage has been given separately. This is because 33 per cent. of all the children examined live in it, and as they are living with only one or two adults, it is not quite the same as the children living in private houses with a relatively large number of adults.

Sex incidence. The equality with which the three types of organism under consideration is distributed between the sexes is remarkable, and is shown in Table V.

TABLE V.

Sex	No.	*E. histolytica*	*E. coli*	*L. intestinalis*
Male	274	4·9	25·1	12·8
Female	218	4·5	23·4	11·9
Sex ?	8	...	...	...

Matthews and Smith (1919), in a small series of seven houses, showed that when one person in a given house is infected, the other members of the same household show a relatively high percentage of infection. The same has been worked out for the present series, and is shown in Table VI.

On account of the large number of houses from which cases have been examined, the details of infection are not given for each house separately. They are shown as average percentages of the infected population. This figure was obtained by working out the percentage of people infected in each house in which infection occurred, and then striking the average of these percentages.

The Orphanage is again given separately, because with its population of seventy-one it would have an undue influence on the totals of the private houses, whose average population per house is only three to four.

TABLE VI.

PRIVATE HOUSES

Type of infection	Total No. of houses examined	No. of houses infected	Percentage	Total population of infected houses	No. of population infected	Average percentage infected per house
E. histolytica	158	13	8·2	64	19	39·5
E. coli	158	66	41·8	223	99	54·2
L. intestinalis	158	25	15·8	95	48	54·3

ORPHANAGE

Type of infection	Total No. of houses examined	No. of houses infected	Percentage	Total population of infected houses	No. of population infected	Average percentage infected per house
E. histolytica	1	1	100	71	4	5·6
E. coli	1	1	100	71	35	49·3
L. intestinalis	1	1	100	71	11	15·5

It appears in the above table that, including the Orphanage, there are one hundred and five houses with infections of one kind or another in them. But the actual number of houses containing infections is only seventy-five, because some houses have two or all types of infection in them. Similarly among the people two hundred and sixteen infections are distributed between one hundred and eighty-five individuals.

Further, it is noticed that the figures in the last column are higher than the percentages which would result from comparing the total population of infected houses and the number of population infected. This is because some houses with only one inhabitant, who is infected, tend to raise the average.

There is no apparent reason why the Orphanage figures do not more closely agree with the averages for the private houses. Nevertheless, they are distinctly higher than the total infections found, as will be seen by comparing them in Table VI with those of Table I.

The fact of the equal liability of the sexes to infection and that of the high incidence of infection in houses which contain infected people, when taken together seem to be of some value, as an indication of the probable mode of spread of infection.

All the adult males are employed in outdoor work, and the females are occupied in house work. Therefore, the infection most likely occurs in the neighbourhood of houses, as outdoor work has no apparent influence on the infection rate, and vice-versa.

Wenyon and O'Connor (1917) in a series of experiments proved that house-flies can act as the carriers of cysts of *E. histolytica*, and when it is remembered that in the houses under consideration all the privies are of the dry-earth type, and by no means fly-proof, the idea of flies being active agents in the spread of infection, at all events in this district, is worthy of consideration.

Origin of the infection. As a result of inquiries among the twenty-three carriers of *E. histolytica*, it is found that, with one exception, they have all lived in their present houses many years, and in most cases all their lives. The one exception was at the war for three years, but never had dysentery or diarrhoea. All except one, who was born in Ireland, and has been in Australia twenty-seven years, were born in this country, and have not been out of it, except the soldier.

Two of them have had attacks of dysentery, both some years ago, one in the present abode, and one in Western Australia. The true nature of these attacks is not obtainable.

No work has been done on returned Australian soldiers to find if there are carriers of *E. histolytica* among them. Nevertheless, it is practically certain they exist, because carriers in the British army have been found by Wenyon (1916), Jepps (1916), Matthews and Smith (1917), Turner and Taylor (1919), and many others. And the same has been found in the American army by Kofoid and others (1919). Australian soldiers were living under identical conditions as the soldiers of the above two armies, and, further, many of them had dysentery. It is, therefore, reasonable to assume that there are carriers among them. But H. Johnston (1909) has collected records of six or seven cases of amoebic dysentery or liver abscess occurring in Australia prior to that date. Therefore, *E. histolytica* has probably existed in Australia for many years, and, as in many other countries, only occasionally causes disease. Consequently, the almost certain introduction of a large number of carriers among the returned soldiers need not necessarily be followed by an increase in incidence of the disease.

Special considerations. E. hystolytica has shown nothing worthy of special notice. *E. coli*: Small cysts of this organism have been relatively common. By small cysts is meant those from 11μ to 14μ. This in a total of one hundred and thirty-four infections, a high proportion, as shown by Smith (1919). *L. intestinalis* has been found about an equal number of times in each of the two types described by Matthews (1918), viz., the usually described, brown-staining variety in iodine, and the smaller bluish type described by the above observer. They either occurred alone or both in the same stool. *T. mesnili* in some stained preparations showed the chromatin of the nucleus evenly distributed around the nuclear membrane, and hence did not present the 'signet-ring' type of nucleus described by Matthews (1918) as typical. *Entamoeba nana* (Wenyon) was not found at all. This is somewhat strange, as it seems to occur in most other parts of the world, in company with the protozoa found at this examination. But the number of cases examined is too small on which to make a definite pronouncement as to its presence or absence in Australia, and it will very likely appear at subsequent examinations. *I. cysts* (Wenyon) were encountered five times. In one case these cysts, with the iodine vacuole distinct, were seen at the serial examination. But when the same case was examined after treatment for *Agchlystoma duodenale*, large numbers of the same cysts were seen, but on this occasion none showed the iodine vacuole.

Blastocystis hominis was fairly common, more especially when reasonably fresh stools were examined. The actual number of times it occurred was not recorded. A single rather interesting observation in connection with this cyst has been noted. A case that showed large numbers of *I. cysts* in a formed stool at the serial examination was again examined after treatment for *A. duodenale*, when the stool was liquid. On the second examination no *I. cysts* were found, but the stool was full of *B. hominis*, none of which were found at the first examination. Wenyon (1917) mentions the development of *B. hominis* and diarrhoea concurrently in a case he was controlling for *E. coli*, and suggests a possible connection between the two, but draws no definite conclusion. The above case, observed at Townsville, raises the question whether *B. hominis* may not appear because of the diarrhoea artificially induced. And the same thing may have occurred in Wenyon's case, although there the diarrhoea was not brought on by the use of drugs. But O'Connor (1919), in a later paper, seems to trace some connexion between *B. hominis*, *I. cysts*, and some other vegetable cysts, and a special form of diarrhoea of which he has observed fifteen cases.

'*? cysts*.' In fresh preparations, both in saline and iodine solution, this cyst was to all appearance very like *E. nana*. It is a small cyst varying in shape from a distinct oval to one almost circular. It is 5μ to 12μ in its long diameter, and contains a few refractile granules, which might easily be mistaken for indistinct nuclei, such as are seen in *E. nana*. But in preparations stained with iron-haematoxlyn the granules are seen as small, darkly-staining dots, which are quite homogeneous and show no nuclear structure. They vary from one to seven in number. After prolonged search of stained preparations a few budding forms were found, thus definitely proving its vegetable origin. Attention has only been drawn to it because of its likeness to *E. nana*.

Eggs of the following intestinal worms were found during the course of the examination, viz. :—*Agchylostoma duodenale*, *Oxyuris vermicularis*, *Trichuris trichiura*, and those of a *Hymenolepis* sp. (probably *H. nana*). The larvae of *Strongyloides stercoralis* were fairly often encountered.

The number of times these infections occurred is not given because many are missed when the stools are not centrifugalised, and, further, they will be published in full, and for a much greater number of cases, in the reports of the 'Hookworm Campaign.'

SUMMARY

The protozoa of the human intestine are substantially the same in Australia as in other parts of the world where similar examinations have been carried out, and they occur in approximately the same proportion of cases, among healthy people.

Confirmation is given to the view that the incidence is higher in children and young adults than in people of more mature age.

Evidence has been put forward to show that flies are very probably carriers of the infection.

In conclusion, I wish to express my thanks to Dr. Breinl for his readiness always to discuss doubtful cases, and also for his assistance and suggestions in connection with the literature; and to Dr. Willis, of the 'Hookworm Campaign,' and the members of his staff, for free access to their material, and for obtaining for me any information I required from any of the cases examined.

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PRELIMINARY NOTE ON THE DEVELOPMENT OF THE LARVAE OF *DIROFILARIA IMMITIS* IN DOG FLEAS *CTENOCEPHALUS FELIS* AND *CANIS*

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Dirofilaria immitis (Blanchard 1895) is a parasite commonly found in dogs in and around Townsville, and a number of the animals succumb to the infection with this parasite under similar clinical symptoms to those described from other parts of the world. Microfilariae can usually be seen in the peripheral blood of the infected animals at any hour of the day or night.

The transmission of *Dirofilaria immitis* by mosquitoes has been definitely proved by several writers, and the parasite undergoes its full development of cycle in mosquitoes belonging to such different genera as *Stegomyia*, *Anopheles* and *Culex.*

The fact that this parasite does not require a definite genus of mosquito for the successful completion of its life history, as definitely proved for the majority of protozoal infections, suggested further investigations to ascertain whether other ectoparasites of dogs, such as fleas, offer suitable conditions for the development of the larvae of *Dirofilaria immitis*, when taken up in the infected blood by the fleas.

T. L. Bancroft in Australia, and others in different parts of the world, have suspected *Pulex serraticeps*, but were unable to trace further development of the larvae after the blood containing them was digested.

Fleas were collected from dogs known to harbour the parasite in their peripheral blood, and were dissected in the usual way. As a rule, *Ctenocephalus canis* and *felis* occurred in about the same proportion, but at other times the number of *C. felis* much preponderated. The terminal segment of the flea was snipped on both sides, and by gentle traction the proventriculus, mid-gut and hind-gut with the Malpighian tubes were removed as a whole.

The alimentary canal was teased out on a slide in a small quantity of saline, and the specimen thus obtained fixed before drying in a fixing solution containing equal parts of concentrated picric acid and mercuric chloride, to which acetic acid was added to make it up to a 4 per cent. solution. The films were fixed for a few minutes in this solution, hardened in alcohol of increasing strength and afterwards stained with Ehrlich's haematoxylin. A number of other stains were experimented with, but the results were in no case superior to that obtained with haematoxylin. We were thus able to obtain 'wet' films, which, on microscopical examination, showed structural details not seen in dried specimens.

Whilst dissecting fleas, it was noticed on several occasions that when teasing out the alimentary canal large nematodes escaped from the body cavity which were actively motile, and could not be differentiated from mature filarial larvae such as seen in the infected mosquito.

Fleas collected from an infected dog which contained fresh blood, more or less altered, in their mid-gut, showed, as a rule, filarial larvae in a varying quantity resembling closely the forms seen in the peripheral blood of the dog. In addition, forms were seen with a slightly broadened posterior end (measuring in the stained specimens 6μ to 8μ), whereas the diameter at the anterior end measured about 4μ to 5μ. In many instances the Malpighian tubes of 'infected' fleas contained parasites further developed: small stumpy forms about 90μ to 120μ long and 14μ to 16μ broad with a pointed tail end, longer forms up to 250μ and more in length and up to 30μ in width; in addition, many intermediate stages were seen on different occasions. The large, free forms up to 600μ in length and 20μ to 30μ wide were found now and again free in the body cavity of the flea.

Our experience has thus shown that the larvae of *Dirofilaria immitis* undergo a complete developmental cycle, analogous to that in the mosquito (*Stegomyia fasciata* was used in our experiments) in the dog fleas, *Ctenocephalus canis* and *felis*. The larvae enter the flea with the blood and obtain access to the Malpighian tubes, where the further development takes place. When nearly mature they leave the Malpighian tubes, and are found free in the body cavity.

It was noted that the degree of development depended greatly on the external temperature. During the hot season fully-developed larvae were frequently found, whereas during our cool months the larvae hardly ever developed beyond the early stages, and, as a rule, only blood forms with the broadened posterior end were discovered. However, in addition to temperature, other factors which could not be determined seemed to influence the development.

On several occasions fleas collected from one dog were heavily infected, whereas fleas collected from another dog living in the same surroundings, with approximately the same number of parasites in the peripheral blood, showed only scanty parasites. Even fleas collected from the same dog showed great variation in the infection. The fleas of the same animal would show during one week a large number of forms in all stages, whereas the following week only blood, and perhaps early forms, could be found in the dissections.

In our experience, development of the filarial larvae occurred most often in the female flea; whereas in the male flea, only now and again were early developmental stages discovered.

The mode of transmission was considered, and it was thought possible that under normal conditions the flea would be crushed, and the actively motile larvae thus freed would penetrate through the unbroken skin and reach the blood stream in analogy with the mechanism of *Agchylostoma* infection.

In order to ascertain the correctness of the surmise, fleas were crushed over the shaved skin of young puppies which had been moistened with saline, and after an interval of from five to twenty minutes the part of the skin was excised and serial sections prepared for microscopical examination.

In one instance only out of seven experiments one mature larva was discovered in three consecutive serial sections with the anterior part (about 30μ of the larva) embedded in the subcutaneous tissue, the remaining part adhering to the outer skin. The larva had, without doubt, penetrated through the unbroken skin.

SUMMARY

The experiments carried out have proved that the larvae of *Dirofilaria immitis* can undergo a complete developmental cycle in the dog fleas, *Ctenocephalus felis* and *canis.* A mature larva on one occasion was found to have penetrated the unbroken skin of a puppy, making its way into the subcutaneous tissue.

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ON THE 'ARNETH COUNT' IN HOOKWORM-INFECTED WHITE CHILDREN IN NORTH QUEENSLAND

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In the past, work has been carried out by Breinl and Priestly (1914) on Arneth counts of healthy white school children, who had spent their lives in the tropical parts of North Queensland. The observations proved a decided shift of the Arneth index to the left, when compared with that of normal individuals in Europe. Later, this investigation was extended to healthy aboriginal children in Northern Australia (1917), and, furthermore, to native children in New Guinea (1915), living in an area where malaria, yaws and other parasitic diseases were found to be endemic.

A shift of the Arneth index to the left was found in healthy aboriginal children of North Queensland analogous to that of children of European descent in North Queensland, but a much more pronounced shift was found in the native children of New Guinea.

Taking advantage of recent opportunities, blood smears obtained from white children in North Queensland, suffering from ancylostomiasis were examined in order to determine the Arneth index. A number of the smears were collected by one of the members of the staff of the hookworm campaign, carrying out work at present in North Queensland; others were obtained from children of various ages, who underwent treatment for hookworm infection in the Townsville Hospital.

Previous observations by Knapp (1915) in India showed in the blood of hookworm patients a distinct shift of the Arneth index to the right, but the results, according to his own statement, 'were on the whole equivocal,' and he proposed to carry out further research.

Macfie (1916), working on the Gold Coast, confirmed to a certain extent Knapp's tentative results. Out of seventeen counts made on hookworm patients, about 30 per cent. showed, when compared with those of healthy natives, an actual shift to the right, 41 per cent. had a relative shift to the right, that is, 'a slighter degree of shift to the left than is found in apparently healthy natives,' and 29 per cent. had a definite shift to the left. He concluded from his results that 'there appeared unquestionably a tendency to develop a shift to the right in patients infected with hookworms.'

In the present investigation the same technique was employed as in the previous work; all counts were performed by myself, Dr. Priestly and myself having performed the previous counts. In this way the results, so far as technique is concerned, are comparable with those obtained previously, and the personal source of error has been, so far as possible, excluded.

Two hundred consecutive leucocytes were counted in two sets of 100, and only when the two sets of figures differed but slightly were the counts taken into consideration.

All the children from whom the blood was obtained lived in areas where malaria is practically unknown, and any definite change found must be attributed to the effects of hookworm infection.

The figures (Table I) were separated according to age groups, and the table shows that the averages for the age groups between five and fifteen years are fairly constant. The Arneth index for children two and three years old is much lower, and approaches that found in healthy North Queensland children. The disproportionate rise for children four years of age may be due to the small number of observations. The total averages prove conclusively that the average Arneth index in hookworm-infected children shows a decided shift to the left.

A comparison of the Arneth index of hookworm-infected white children in North Queensland with that of children living in New Guinea shows a striking similarity, and strengthens the assumption that the comparative increase in the Arneth index in the latter locality was due to the great incidence of latent and active infection

Age	Number of children	%						DIFFERENTIAL COUNTS %					
		I	II	III	IV	V	Arneth Index	Poly-morpho-nuclear neutro-phile	Transi-tionals	Large Mono-nuclear	Lympho-cytes	Eosino-philes	Mast cells
years 2	3	30·0	42·5	24·0	3·0	0·5	72·5	38·9	2·7	0·8	44·0	12·41	0·2
3	4	31·0	44·4	18·9	5·2	0·5	75·4	36·1	3·5	0·8	41·1	17·9	0·6
4	2	61·0	34·5	4·3	0·2	—	95·5	41·6	5·5	0·7	29·6	22·1	0·5
5	5	41·3	40·5	15·7	2·4	0·1	81·8	46·98	3·04	0·70	32·78	15·74	0·76
6	12	42·42	40·66	13·87	2·95	0·1	83·08	49·10	2·54	0·52	34·28	12·75	0·81
7	17	42·91	39·95	14·56	2·53	0·05	82·86	54·33	3·01	0·61	30·99	10·72	0·34
8	11	43·81	41·51	12·46	2·18	0·04	85·32	46·31	3·01	0·39	35·74	14·15	0·40
9	14	41·65	41·72	13·90	2·53	0·20	83·37	56·59	2·94	0·88	28·77	10·32	0·50
10	11	45·00	40·09	13·23	1·54	0·14	85·09	58·13	2·61	0·45	27·04	11·34	0·43
11	9	41·12	42·39	13·83	2·66	—	83·51	53·89	2·71	0·32	25·79	16·65	0·64
12	12	42·75	40·50	14·42	2·29	0·04	83·25	57·79	2·74	0·55	29·22	9·22	0·48
13	8	39·94	43·06	14·56	2·31	0·13	83·00	53·62	3·17	0·46	31·74	10·28	0·73
14	9	39·77	40·61	15·89	3·34	0·39	80·38	49·39	3·87	0·61	35·10	10·23	0·80
15	4	45·50	41·50	11·25	1·75	—	87·00	48·62	3·03	0·50	34·43	12·92	0·50
2 to 15	121	42·11	41·05	14·20	2·51	0·13	83·16	51·88	3·00	0·58	31·75	12·22	0·57
Native children of New Guinea, aged 1-10 years	50	42·96	40·90	13·80	2·13	0·21	83·86	40·96	2·47	1·36	42·86	13·24	—
North Queensland school children (white) 7-15 years	150	32·50	42·0	20·6	4·5	0·4	74·5	56·1	4·2	2·4	29·5	7·7	0·04

amongst children, amongst whom hookworm infection is probably widespread.

The significance of the shift of the Arneth index to the left is still uncertain. It is, however, possible that in such diseases as hookworm infection and malaria, where the destruction of red cells goes, for a time at least, hand in hand with an increased activity of the blood-forming organs, the increased activity extends to the new formation of leucocytes, and in consequence a greater number of young leucocytes are met with in the peripheral blood.

The differential counts indicate that in younger children—between two and four years of age—the relative number of polymorphonuclear neutrophile leucocytes is decreased, whereas that of the lymphocytes is increased.

After the seventh year the relative proportion of the various forms of white blood corpuscles is fairly constant.

As is to be expected, the relative increase in the number of eosinophile leucocytes is well pronounced throughout our series of counts.

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An Inquiry into the Effect of High Wet Bulb Temperatures upon the Pulse Rate, Rectal Temperature, Skin-Shirt Temperature and Blood Pressure of Wharf Labourers in North Queensland

BY

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AN INQUIRY INTO THE EFFECT OF HIGH WET BULB TEMPERATURES UPON THE PULSE RATE, RECTAL TEMPERATURE, SKIN-SHIRT TEMPERATURE AND BLOOD PRESSURE OF WHARF LABOURERS IN NORTH QUEENSLAND.

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For life in the tropics the physiological response of the warm blooded animal organism to the increased external temperature is of the greatest practical interest and importance. Under normal conditions the temperature equilibrium is maintained by heat production and heat loss; the former is brought about by chemical means, namely, by the combustion of food material in the body, the latter by physical means, namely, by radiation and convection and by evaporation of sweat. Radiation and convections, however, play a comparatively unimportant rôle in the heat regulating mechanism of the clothed human being in the tropics, where the outer temperature is high and frequently approaches that of the body; under these conditions the human organism relies for its cooling mainly on the heat loss due to the evaporation of sweat.

The study of the question of how far evaporation of sweat under varying conditions can compensate for the greatly decreased loss accounted for by convection and radiation is of scientific and of still greater practical interest for tropical colonization.

Haldane (1905) was the first to carry out systematic experiments in this direction by exposing men to different degrees of moist heat in artificially heated chambers and in deep mines, in still and in moving air. He observed that the temperature of the human body exposed to high temperatures began to rise after periods varying according to the individual, this rise corresponding to the rise in the wet bulb readings. He considered the critical temperature during complete rest to be 31.1° C. wet bulb. When the outer temperature rose higher, the rectal temperature began to rise, accompanied by an increase in the pulse rate, by profuse sweating and dyspnœa. During muscular exercise in still air the critical temperature was 27° C.; in moving air, however, higher temperatures were required to produce the same symptoms.

In Townsville similar experiments were carried out under natural and artificial conditions by Young, Breinl, Harris and Osborne. In general the results obtained under artificial conditions confirmed Haldane's observation.

For comparison experiments on the effects of exercise on hot summer days (wet bulb ranging between 24.5° and 27° C.) were carried out. The exercise consisted in hill climbing and walking on the flat at a pace of about four miles per hour. The rectal temperature rose considerably during the first half hour or so and afterwards either remained stationary or continued to rise gradually. A body temperature of 38.8° to 39.4° C. was not a rare occurrence after walking from 33 minutes to two hours at a normal pace. The blood pressure as a rule showed an initial sharp rise and afterwards in some instances remained stationary, but more often fell gradually to the starting level or even below it. The pulse-rate rose rapidly at first, more gradually afterwards, but on several occasions showed a distinct fall.

The loss in weight owing to profuse sweating was considerable and amounted in one instance to nearly 4% of the body weight after a walk lasting 3½ hours.

In continuation of this work similar observations were carried out on men doing manual labour under natural conditions during the hot months in Townsville, the climatic conditions of which corresponds, according to Griffith Taylor (1918), to those in Calcutta, with the exception that the humidity is slightly lower.

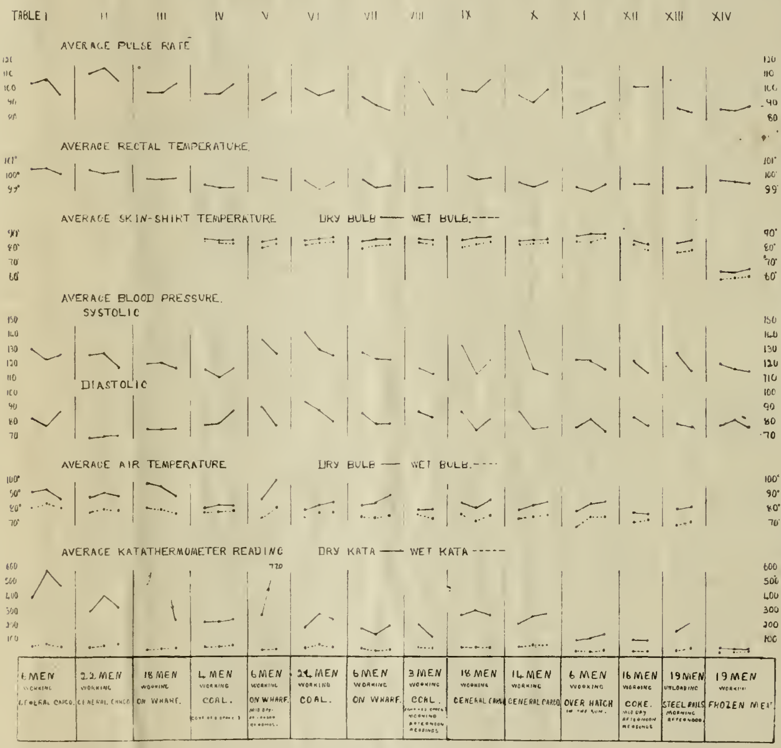
The courtesy of the shipping companies and the members of the Waterside Workers' Union enabled me to collect pulse-rates, rectal temperatures, skin shirt temperatures and systolic and diastolic blood pressure of groups of men working cargo in the ships' holds on the wharf. At the same time, the atmospheric conditions were estimated by utilizing dry and wet bulb thermometer and dry and wet bulb katathermometer readings. The katathermometer is an instrument designed by Leonard Hill primarily for the measurements of its own rate of cooling when its temperature approximates to that of the body temperature; the time in seconds is estimated in which the dry and wet katathermometer take to cool from 43.3° C. to 37.7° C. and again from 37.7° C. to 32.2° C.. The katathermometer readings are the averages calculated from a number of estimations. On account of the slow cooling rate of the dry katathermometer, the time has been estimated which it takes to cool from 43.3° C. to 37.7° C., whereas for the wet katathermometer both the time taken to cool from 43.3° to 37.7° C. and from 37.7° to 32.2° C. has been tabulated.

The blood pressure was taken by means of a Tyco's sphygmomanometer, which has been tested against a mercury manometer.

The skin shirt temperature constitutes the temperature of the air inside the clothing. There is invariably a layer of stagnant air of higher temperature and at a greater degree of saturation with moisture between the clothing and the skin. These temperatures have been taken by means of two ordinary thermometers, the mercury end of one of them wrapped up with a piece of moist fabric and both protected by means of a wire cage which prevented a direct contact with the skin.

All the body temperatures recorded in the following pages are rectal temperatures, since mouth temperatures are unreliable for estimating the actual internal temperature of the body. The observations were carried out in the places where the work was in progress, the men interrupting their work for the space of time required by the investigation. The time of taking the observations had to conform with the working hours; the men as a rule start work at 8 o'clock in the morning and have their dinner hour between one and two o'clock. As far as possible three readings were taken, the first at about 8.30 a.m., the second towards mid-day and the third in the afternoon; in some instances, for other reasons, only two readings could be obtained.

In all about 180 men were thus examined in groups varying from three to twenty-four; for comparison similar observations were carried out on men loading frozen meat at a temperature below freezing point. As might be expected, the men on the latter occasion were heavily clad, wearing warm underclothing and had their boots tied up with sacking. The individual figures obtained have been compiled in form of tables (Table I. to XIV.). From these tables averages were calculated and graphically represented (see Graph I.).



Graph I..

It was assumed that even considering the individual variations any constant tendency to change in the physiological functions under investigation, would find a clear expression in the total averages.

The graphs have been arranged according to the degree of wet bulb temperatures of the air, which varied between 28.8° C. and 21.6° C.; the results obtained at the highest wet bulb readings are presented in the beginning of the graph and the last set of curves represents the results of the examination of 19 men working below freezing point. It is of interest to note that variations are less pronounced in the average wet bulb katathermometer readings than in the dry katathermometer readings. The tables are numbered in the same sequence. The readings of the dry and wet bulb thermometers and of the katathermometers invariably represented the average of a number of readings. The ages of the men varied from about 24 to 62 and quite a number of them had followed the occupation of wharf labourers for a great number of year. All of the men included in the 14 groups carried out the same type of labour; they either worked general cargo, which consists in moving the cases, etc., into a sling, securing it and getting the sling or parachute ready for being lifted up or shovelled coal or coke into baskets holding about 250 kilograms of coal; the men on the wharf received the cargo out of the sling or parachute, put it on trucks and wheeled it into the shed, where it is stacked.

The work on the whole can be considered heavy manual labour and, according to an average estimate each man handles about 2,000 kilograms per hour.

The men on hot days (wet bulb temperature 26.5° C. and over) were only clad in a pair of trousers, boots and a hat when working fully exposed to the sun and had their upper body naked; on cooler days the majority wore either a heavy flannel or a cotton singlet; the men on the wharf were invariably dressed in singlet and trousers and boots.

A consideration of the detailed tables reveals that individual differences in respect of pulse rate, rectal temperature and blood pressure were well marked, whereas the skin shirt temperature did not show such pronounced variations.

Pulse Rate.

With increased wet bulb temperature the pulse rate was higher. On the hottest days the pulse rate rose at mid-day, but fell again in the afternoon, whereas during the somewhat cooler days there was a slight fall towards mid-day and a rise again in the afternoon; on cool days (12 and 13) the average pulse rate remained fairly constant.

Body Temperature.

The rectal temperature, like the pulse rate, showed a general tendency to be at a higher level with increased wet bulb temperature and rectal temperatures in the vicinity of 38.3° C. are quite of usual occurrence on hot days, but are hardly ever registered on cool days. Generally towards midday the average temperature fell slightly, but rose again in the afternoon to the level observed in the morning.

The skin shirt temperature (wet and dry bulb) were closer together on a hot day; in other words, the men were working in a more humid atmosphere, the layer of the air between skin and clothing being nearly saturated with moisture and was higher in men working exposed to the sun (Table VII. and XI.). In spite of the much heavier clothing the skin shirt temperature of the men working in the refrigerating chamber was nearly 10° below that of the men working exposed to the heat of the day.

The blood pressure on the whole was not affected in a constant way by the level of the wet bulb readings. Towards mid-day the systolic blood pressure was nearly always lower than in the morning, but

TABLE I.—SIX MEN WORKING GENERAL CARGO.

ote. —In this and subsequent tables, temperatures are given in the Fahrenheit scale instead of the Centigrade scale.

	Pulse Rate.			Rectal Temperature.			Blood Pressure.					
							Systolic.			Diastolic.		
	Morning.	Noon.	Afternoon.	Morning. F.	Noon. F.	Afternoon. F.	Morning. mm.	Noon. mm.	Afternoon. mm.	Morning. mm.	Noon. mm.	Afternoon. mm.
	104	116	96	101.8°	101.7°	100.0°	150	138	143	84	80	100
	84	84	96	100.7°	100.6°	100.6°	124	120	132	90	70	95
	100	108	72	99.9°	100.2°	100.5°	150	138	120	100	100	90
	112	112	112	100.4°	100.2°	99.5°	104	112	120	60	80	78
	112	108	100	100.7°	100.7°	100.2°	140	116	132	92	66	84
	124	124	112	100.7°	100.6°	100.7°	124	124	120	80	80	90
vg.	106	109	98	100.7°	100.7°	100.3°	132	125	128	84	79	89

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
forning	93.8°	82.6°
oon..	95.5°	85.8°
fternoon	88.2°	82.6°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning..	411 seconds	79 seconds	149 seconds
Noon	598 seconds	88 seconds	168 seconds
Afternoon	490 seconds	68 seconds	128 seconds

TABLE II.—TWENTY-TWO MEN WORKING GENERAL CARGO.

	Pulse Rate.			Rectal Temperature.			Blood Pressure.					
							Systolic.			Diastolic.		
	Morning.	Noon.	Afternoon.	Morning. F.	Noon. F.	Afternoon. F.	Morning. mm.	Noon. mm.	Afternoon. mm.	Morning. mm.	Noon. mm.	Afternoon. mm.
	120	148	96	100.7°	101.4°	101.8°	128	100	140	90	60	60
	104	128	120	100.2°	100.1°	99.8°	130	145	120	80	70	70
	66	84	90	100.0°	100.5°	100.7°	120	120	144	70	80	90
	156	128	126	100.7°	100.7°	101.7°	118	180	128	60	80	80
	114	72	108	99.7°	99.7°	100.6°	112	112	100	70	60	70
	126	152	124	100.3°	101.6°	101.7°	138	130	110	90	90	50
	102	104	102	100.1°	100.3°	100.0°	130	138	100	70	72	50
	108	114	108	101.4°	100.5°	100.2°	149	128	124	60	60	78
	114	96	108	100.6°	100.2°	100.2°	151	126	124	60	60	78
	102	96	90	100.6°	99.6°	100.3°	121	86	104	65	—	60
	123	102	96	100.4°	99.6°	100.4°	125	134	120	75	80	70
	84	84	90	100.1°	99.6°	100.6°	128	128	108	50	70	72
	112	128	102	100.9°	100.5°	100.3°	119	131	130	60	60	70
	116	116	126	100.4°	100.5°	100.7°	143	141	128	80	63	80
	124	132	120	100.7°	100.5°	100.2°	108	110	98	74	70	60
	120	120	120	100.4°	100.2°	100.1°	153	120	96	60	73	60
	100	108	96	100.9°	100.6°	100.2°	119	128	98	60	80	60
	104	138	96	100.2°	100.0°	100.3°	134	130	124	90	73	80
	84	120	114	—	—	—	122	110	110	70	60	70
	128	132	114	—	100.5°	100.1°	145	154	142	90	90	98
	155	138	126	101.2°	100.9°	100.5°	130	154	164	90	88	110
	128	128	108	101.7°	101.1°	100.6°	104	130	122	50	78	70
g.	113	117	108	100.6°	100.4°	100.5°	128	129	119	71	72	72

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
orning	90.1°	79.9°
on..	93.0°	81.8°
ternoon	90.9°	80.9°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning..	308 seconds	64 seconds	120 seconds
Noon	426 seconds	72 seconds	143 seconds
Afternoon	339 seconds	79 seconds	142 seconds

TABLE III.—EIGHTEEN MEN WORKING ON WHARF.

Pulse Rate.			Rectal Temperature.			Blood Pressure.					
						Systolic.			Diastolic.		
Morning.	Noon.	Afternoon.	Morning. F.	Noon. F.	Afternoon. F.	Morning. mm.	Noon. mm.	Afternoon. mm.	Morning. mm.	Noon. mm.	Afternoon. mm.
104	92	104	99.7°	99.7°	100.2°	134	102	124	82	82	80
104	96	116	100.0°	100.3°	100.7°	128	112	110	70	60	50
78	104	100	100.2°	99.7°	100.1°	144	160	140	92	90	105
116	92	100	99.6°	99.6°	99.8°	154	130	142	100	80	105
124	100	120	99.2°	99.4°	99.4°	124	120	136	66	60	100
92	92	116	100.0°	100.4°	100.7°	132	124	139	84	85	80
128	100	100	100.7°	99.0°	100.3°	116	130	120	73	80	80
109	116	124	100.6°	100.6°	100.7°	112	132	122	70	90	70
112	100	112	101.2°	99.7°	100.7°	126	114	115	80	75	60
88	96	92	99.4°	99.2°	99.6°	100	110	104	74	84	50
112	112	112	99.4°	99.3°	99.5°	134	144	120	97	90	90
106	112	116	99.5°	100.0°	99.8°	100	114	112	50	80	80
96	100	100	100.0°	100.7°	100.1°	124	120	110	90	70	80
92	92	100	99.4°	99.5°	100.0°	106	100	102	70	70	68
100	116	104	101.2°	100.5°	100.7°	98	150	90	60	80	65
66	80	88	100.7°	100.2°	101.1°	124	104	116	90	60	75
96	124	116	100.4°	100.4°	100.8°	132	138	132	72	90	70
72	84	84	99.7°	99.6°	99.3°	107	104	114	74	60	86
Avg. 100	100	106	100.0°	99.8°	100.2°	122	123	119	77	77	77

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
Morning	99.7°	82.6°
Noon	97.1°	81.6°
Afternoon	90.9°	79.0°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F
Morning	496 seconds	48 seconds	124 secon
Noon	—	53 seconds	124 secon
Afternoon	249 seconds	56 seconds	110 secon

TABLE IV.—FOUR MEN WORKING COAL.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn. F.	Noon. F.	A'noon. F.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. F.	Noon. F.	A'noon. F.	Morn. F.	Noon. F.	A'n F
72	72	92	99.3°	99.1°	99.0°	100	100	120	60	74	92	89.4°	87.7°	85.7°	86.9°	85.5°	84
100	104	96	100.0°	99.9°	99.1°	140	130	142	110	98	108	88.2°	88.2°	88.2°	87.8°	87.5°	85
96	96	96	99.2°	99.3°	99.4°	100	110	100	60	80	70	88.4°	88.2°	89.8°	87.3°	88.2°	87
128	124	140	99.8°	99.3°	99.8°	130	112	114	90	74	90	88.2°	86.4°	86.6°	86.6°	85.3°	86
Av. 99	99	106	99.6°	99.4°	99.4°	118	113	119	80.	81	90	88.6°	87.6°	87.6°	87.1°	86.6°	85

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
Morning	82.9°	79.4°
Noon	84.8°	80.3°
Afternoon	84.1°	80.5°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F
Morning	235 seconds	65 seconds	114 secon
Noon	237 seconds	68 seconds	123 secon
Afternoon	244 seconds	76 seconds	132 secon

TABLE V.—SIX MEN WORKING ON WHARF.

Pulse Rate.		Rectal Temperature.		Blood Pressure.				Skin-Shirt Temperature.			
				Systolic.		Diastolic.		Dry Bulb.		Wet Bulb.	
Morning.	Afternoon.	Morning. F.	Afternoon. F.	Morning. mm.	Afternoon. mm.	Morning. mm.	Afternoon. mm.	Morning. F.	Afternoon. F.	Morning. F.	Afternoon. F.
96	72	99.8°	99.6°	140	120	100	80	84.9°	86.2°	82.6°	81.5°
84	92	99.6°	99.7°	156	136	84	60	85.7°	89.4°	82.4°	87.7°
108	132	99.4°	100.1°	144	140	104	80	86.0°	89.8°	80.6°	85.9°
88	116	100.6°	99.3°	124	122	90	85	85.1°	87.8°	82.6°	85.3°
96	84	100.2°	99.9°	120	134	86	90	86.9°	87.7°	84.2°	83.7°
96	104	100.8°	100.8°	150	122	90	80	87.8°	87.8°	83.7°	85.9°
Avg. 95	100	100.1°	99.9°	139	129	92	79	86.1°	88.1°	82.7°	85.0°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
Morning	88.6°	75.2°
Afternoon	102.1°	82.8°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning	286 seconds	45 seconds	143 seconds
Afternoon	770 seconds	46 seconds	68 seconds

TABLE VI.—TWENTY-FOUR MEN WORKING COAL.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn. F.	Noon. F.	A'noon. F.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. F.	Noon. F.	A'noon. F.	Morn. F.	Noon. F.	A'noon. F.
88	84	80	100.3°	99.3°	99.4°	129	138	126	90	90	90	87.5°	85.5°	89.8°	86.0°	82.2°	85.3°
108	88	104	99.8°	100.4°	100.6°	142	140	150	100	100	100	86.0°	89.2°	89.2°	82.6°	86.8°	85.1°
124	100	128	99.7°	99.2°	100.1°	160	124	145	80	88	85	84.8°	89.6°	89.8°	82.0°	85.7°	86.2°
112	88	108	100.3°	99.0°	99.7°	134	114	142	95	60	100	86.9°	88.2°	89.6°	85.7°	85.3°	85.9°
128	104	112	100.8°	99.6°	101.2°	132	104	102	80	65	50	89.0°	88.6°	89.4°	89.0°	86.6°	87.8°
120	112	112	100.1°	99.0°	100.1°	112	126	92	72	70	54	87.8°	89.2°	89.4°	86.6°	86.9°	86.6°
84	84	84	100.8°	99.4°	99.1°	178	160	124	140	115	80	88.4°	90.7°	92.3°	86.0°	88.0°	89.8°
140	116	120	100.5°	99.0°	100.2°	184	158	126	132	130	70	88.2°	90.0°	90.9°	86.9°	88.0°	89.0°
92	92	88	99.2°	98.1°	99.3°	150	120	122	120	70	60	86.2°	89.4°	91.2°	85.1°	87.3°	88.4°
92	80	84	99.6°	99.2°	99.2°	150	134	102	100	76	64	88.0°	88.4°	90.9°	87.3°	86.9°	88.7°
112	112	108	100.2°	99.1°	99.6°	158	138	104	120	105	65	87.3°	89.2°	90.7°	86.0°	84.4°	87.3°
96	84	104	99.9°	99.3°	99.7°	175	156	124	120	120	86	86.6°	88.0°	89.8°	86.2°	84.0°	87.1°
120	108	96	99.0°	99.6°	99.8°	156	140	152	96	100	100	87.8°	90.2°	88.2°	83.1°	84.4°	86.0°
108	104	92	99.8°	99.7°	99.3°	126	118	146	84	90	100	84.2°	88.0°	86.4°	81.8°	84.4°	83.0°
92	92	100	99.9°	99.6°	99.8°	172	170	150	120	120	104	87.8°	88.4°	87.1°	86.4°	85.1°	84.2°
72	88	80	99.3°	99.9°	99.3°	136	132	130	100	94	80	86.2°	88.4°	87.8°	83.9°	86.2°	85.5°
92	84	92	99.8°	99.6°	100.2°	158	120	148	90	90	100	86.6°	88.4°	88.0°	85.5°	84.9°	87.3°
92	80	126	99.8°	98.4°	99.2°	110	116	132	84	70	80	86.6°	87.7°	86.9°	82.6°	83.0°	84.0°
92	96	92	99.7°	99.4°	100.1°	122	110	124	80	74	80	86.2°	87.8°	89.2°	84.8°	85.9°	81.8°
124	114	108	99.8°	99.4°	100.0°	134	121	104	76	80	70	88.2°	89.0°	89.6°	85.3°	86.4°	87.5°
108	104	96	99.8°	99.5°	99.9°	144	140	144	110	100	95	85.1°	88.7°	88.6°	80.0°	87.1°	87.3°
104	90	100	100.1°	99.6°	100.5°	150	160	148	70	120	100	86.2°	88.7°	87.7°	81.8°	86.9°	84.4°
108	128	108	99.3°	99.8°	99.5°	162	152	150	96	96	94	87.3°	88.0°	88.0°	81.6°	84.8°	86.0°
72	84	88	99.4°	98.8°	99.5°	84	76	98	50	48	60	90.5°	88.4°	89.6°	85.7°	85.7°	88.0°
Av.103	98	101	99.9°	99.3°	99.8°	144	132	128	96	90	82	87.1°	88.7°	89.2°	84.6°	85.7°	86.4°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
Morning	81.5°	76.3°
Noon	84.3°	79.2°
Afternoon	86.6°	79.7°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning	193 seconds	53 seconds	83 seconds
Noon	294 seconds	75 seconds	138 seconds
Afternoon	257 seconds	69 seconds	118 seconds

Table VII.—Six Men Working on Wharf.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn. F.	Noon. F.	A'noon. F.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. F.	Noon. F.	A'noon. F.	Morn. F.	Noon. F.	A'noon. F.
96	96	84	100.1°	100.3°	100.2°	112	84	100	80	56	70	84.2°	86.2°	85.5°	78.8°	78.8°	79.7°
108	72	84	99.5°	98.6°	99.2°	158	150	140	100	90	92	84.6°	86.2°	88.0°	79.2°	82.0°	84.6°
100	116	84	99.5°	99.1°	99.2°	126	152	140	80	100	92	84.2°	87.8°	88.0°	78.4°	81.8°	84.6°
84	80	84	100.6°	99.5°	99.4°	154	124	140	100	60	90	84.4°	—	85.7°	78.6°	—	79.0°
84	76	76	99.4°	99.5°	99.4°	122	140	128	100	100	80	84.6°	88.2°	80.8°	78.6°	80.0°	78.8°
108	108	108	100.0°	99.2°	99.7°	108	108	102	70	80	60	86.6°	88.0°	86.9°	80.8°	81.0°	80.8°
Av. 97	91	87	99.8°	99.4°	99.5°	130	126	125	88	81	81	86.6°	88.6°	88.1°	81.8°	83.6°	84.4°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
Morning	84.1°	76.5°
Noon	86.1°	75.8°
Afternoon	92.0°	77.8°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning	194 seconds	51 seconds	81 seconds
Noon	155 seconds	40 seconds	61 seconds
Afternoon	217 seconds	47 seconds	84 seconds

Table VIII.—Three Men Working Coal.

Pulse Rate.		Rectal Temperature.		Blood Pressure.				Skin-Shirt Temperature.			
				Systolic.		Diastolic.		Dry Bulb.		Wet Bulb.	
Morning.	Afternoon.	Morning. F.	Afternoon. F.	Morning. mm.	Afternoon. mm.	Morning. mm.	Afternoon. mm.	Morning. F.	Afternoon. F.	Morning. F.	Afternoon. F.
96	92	99.1°	99.6°	102	117	78	80	86.9°	88.2°	85.9°	85.1°
100	84	99.5°	99.2°	130	112	102	90	88.6°	84.4°	87.1°	82.6°
128	96	99.6°	99.3°	124	116	86	86	89.2°	88.7°	86.6°	86.8°
Avg. 108	91	99.4°	99.4°	119	115	89	85	88.2°	87.1°	86.5°	84.8°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
Morning	81.8°	78.0°
Afternoon	81.7°	75.7°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning	244 seconds	69 seconds	117 seconds
Afternoon	135 seconds	57 seconds	92 seconds

TABLE IX.—EIGHTEEN MEN WORKING GENERAL CARGO.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.
			F.	F.	F.	mm.	mm.	mm.	mm.	mm.	mm.	F.	F.	F.	F.	F.	F.
124	112	112	100.0°	100.1°	99.9°	114	124	120	85	90	82	87.8°	88.2°	90.4°	86.2°	82.4°	87.8°
96	100	120	99.8°	99.7°	100.3°	140	122	120	90	90	90	89.6°	88.0°	91.4°	86.9°	83.7°	86.0°
86	88	88	100.7°	100.2°	99.9°	110	108	140	60	60	100	86.9°	88.2°	—	82.4°	85.3°	—
72	64	92	100.2°	99.4°	100.7°	114	100	124	85	70	80	87.5°	86.4°	89.6°	83.0°	81.5°	83.7°
128	104	124	100.4°	100.1°	101.3°	146	112	115	112	86	80	87.3°	88.7°	90.0°	82.6°	82.4°	84.4°
84	88	116	99.4°	99.6°	99.9°	138	130	142	100	80	90	—	—	—	—	—	—
96	96	100	100.3°	99.7°	101.7°	149	102	134	110	70	70	86.0°	86.9°	86.6°	81.6°	82.2°	81.8°
100	96	100	100.8°	100.4°	100.5°	138	120	130	100	80	64	—	—	—	—	—	—
116	108	108	100.7°	99.3°	100.3°	122	112	100	80	70	60	—	—	89.2°	—	—	84.0°
132	140	132	101.7°	100.0°	100.9°	120	106	92	96	50	70	86.0°	88.0°	89.0°	82.4°	83.9°	84.2°
100	88	104	100.5°	99.2°	100.9°	140	124	130	85	70	100	—	—	—	—	—	—
120	104	112	101.6°	99.9°	99.8°	129	124	126	90	90	90	—	—	—	—	—	—
92	108	108	100.5°	100.5°	100.7°	140	120	138	105	80	100	86.8°	92.1°	88.6°	80.6°	88.4°	86.6°
92	96	120	100.5°	100.8°	101.4°	140	112	139	105	80	110	86.8°	90.9°	88.7°	80.6°	87.1°	88.4°
100	108	—	100.6°	99.8°	—	130	104	—	70	80	—	87.8°	90.0°	—	83.3°	84.8°	—
108	92	100	99.6°	99.3°	98.4°	160	120	130	108	80	90	88.0°	89.2°	88.4°	84.0°	83.9°	87.3°
92	108	108	100.2°	100.5°	100.6°	164	130	110	120	90	70	88.0°	90.0°	89.8°	82.6°	87.5°	89.0°
92	108	116	100.6°	99.6°	100.3°	126	96	128	94	50	84	89.0°	91.6°	89.4°	84.6°	88.4°	88.0°
Av.102	100	109	100.4°	99.9°	100.4°	135	115	125	89	76	84	87.5°	89.1°	89.2°	83.1°	84.7°	86.1°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
orning	86.9°	78.2°
oon..	82.9°	73.9°
fternoon	88.3°	77.3°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning..	283 seconds	69 seconds	129 seconds
Noon	321 seconds	66 seconds	122 seconds
Afternoon	285 seconds	62 seconds	77 seconds

TABLE X.—FOURTEEN MEN WORKING GENERAL CARGO.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.	Morn.	Noon.	A'noon.
			F.	F.	F.	mm.	mm.	mm.	mm.	mm.	mm.	F.	F.	F.	F.	F.	F.
92	80	100	100.5°	100.0°	100.0°	168	144	95	102	80	60	85.3°	87.1°	86.9°	84.2°	84.9°	84.2°
88	72	92	100.3°	99.6°	100.4°	118	110	111	80	67	70	85.7°	87.8°	88.2°	83.7°	86.2°	85.9°
76	68	84	100.1°	99.8°	99.4°	150	122	136	100	86	94	86.6°	88.4°	87.3°	84.2°	87.5°	84.4°
132	132	125	98.6°	98.4°	99.8°	160	130	110	120	84	75	88.0°	88.0°	88.0°	85.7°	85.5°	86.4°
88	96	88	100.0°	99.8°	99.6°	188	140	140	110	110	110	86.2°	87.1°	86.2°	84.0°	85.9°	83.9°
08	105	112	100.3°	99.2°	100.2°	178	110	140	112	66	114	89.6°	88.0°	88.0°	85.7°	85.9°	84.0°
16	108	124	99.6°	99.4°	100.7°	142	132	124	80	100	90	86.2°	86.2°	87.1°	82.8°	82.4°	85.7°
96	100	124	99.5°	99.6°	100.7°	140	110	124	70	80	90	86.0°	85.9°	87.1°	83.9°	81.3°	85.7°
88	88	92	99.8°	99.0°	99.2°	120	102	104	70	40	50	85.3°	88.0°	86.0°	83.0°	83.9°	84.0°
84	80	96	99.8°	99.8°	100.2°	143	124	104	90	60	70	87.8°	88.0°	88.0°	85.5°	84.2°	86.4°
88	92	104	100.0°	100.2°	100.6°	134	100	110	74	60	60	86.4°	88.0°	88.7°	85.1°	86.8°	86.4°
92	76	100	99.4°	98.8°	99.2°	106	108	106	60	80	60	87.3°	86.4°	88.0°	85.7°	85.5°	86.4°
28	124	116	98.4°	98.4°	99.0°	176	114	112	100	80	84	87.5°	86.8°	89.8°	85.1°	83.7°	86.6°
84	76	76	99.0°	99.4°	98.6°	104	120	94	80	92	65	89.6°	88.0°	87.8°	86.9°	85.7°	85.1°
v. 97	93	102	99.7°	99.4°	99.8°	145	119	115	89	77	78	87.0°	87.4°	87.7°	84.7°	84.9°	85.4°

Average Air Temperature.

	Dry Bulb.	Wet Bulb.
	F.	F.
orning	81.4°	75.2°
oon..	84.2°	76.4°
fternoon	86.5°	77.7°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning..	229 seconds	65 seconds	112 seconds
Noon	276 seconds	72 seconds	130 seconds
Afternoon	291 seconds	72 seconds	121 seconds

TABLE XI.—SIX MEN WORKING OVER HATCH.

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn. F.	Noon. F.	A'noon. F.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. F.	Noon. F.	A'noon. F.	Morn. F.	Noon. F.	A'noon F.
84	76	92	99.6°	99.5°	100.2°	126	134	140	70	100	100	89.0°	91.6°	91.6°	85.5°	87.7°	90.0°
88	88	92	99.6°	99.2°	99.2°	120	120	110	60	90	70	90.2°	92.0°	91.4°	85.9°	87.3°	88.9°
84	92	80	99.5°	99.1°	99.6°	116	124	102	80	80	70	91.4°	91.6°	92.8°	86.6°	86.2°	89.0°
92	96	96	99.4°	98.4°	99.7°	97	112	104	60	80	66	91.2°	90.7°	91.6°	87.5°	83.7°	89.0°
72	80	88	99.0°	99.2°	99.0°	144	122	114	100	70	70	91.2°	91.4°	91.4°	87.3°	85.1°	89.0°
88	100	108	99.6°	99.3°	100.2°	147	134	136	100	85	76	90.5°	91.1°	90.2°	86.2°	88.2°	87.7°
Av. 85	89	93	99.4°	99.1°	99.6°	125	124	118	78	84	75	90.6°	91.4°	91.5°	86.5°	86.4°	88.9°

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
Morning	80.0°	69.5°
Noon..	85.6°	76.6°
Afternoon	86.5°	76.2°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning..	112 seconds	35 seconds	49 seconds
Noon	123 seconds	32 seconds	57 seconds
Afternoon	157 seconds	41 seconds	53 seconds

TABLE XII.—SIXTEEN MEN WORKING COKE.

Pulse Rate.		Rectal Temperature.		Blood Pressure.				Skin-Shirt Temperature.			
				Systolic.		Diastolic.		Dry Bulb.		Wet Bulb.	
Noon.	Afternoon.	Noon. F.	Afternoon. F.	Noon. mm.	Afternoon. mm.	Noon. mm.	Afternoon. mm.	Noon. F.	Afternoon. F.	Noon, F.	Afternoon. F.
96	108	99.2°	100.0°	158	154	116	120	83.0°	81.3°	80.8°	77.2°
88	92	98.6°	99.1°	98	90	78	54	84.9°	84.6°	83.5°	79.2°
124	112	99.6°	99.0°	114	110	80	70	86.8°	85.7°	85.1°	82.0°
104	116	99.8°	99.7°	108	132	70	100	88.0°	85.9°	86.4°	81.0°
88	80	99.4°	99.7°	134	134	90	108	84.8°	84.4°	81.8°	79.2°
108	112	98.2°	99.6°	120	112	92	54	82.8°	83.9°	81.0°	79.7°
104	96	100.2°	99.6°	112	98	74	60	88.2°	84.0°	86.2°	80.0°
132	116	100.0°	99.4°	120	120	80	70	88.0°	85.9°	86.0°	81.8°
76	80	99.4°	99.2°	138	104	103	76	88.0°	83.5°	87.8°	77.6°
104	92	99.4°	99.0°	114	110	90	72	85.9°	82.6°	83.7°	77.7°
132	104	100.4°	99.5°	106	122	62	80	88.2°	83.0°	85.9°	80.2°
96	92	100.3°	100.2°	132	120	90	82	87.5°	85.1°	85.9°	82.0°
100	96	99.1°	99.8°	154	144	100	84	88.0°	85.5°	86.2°	83.1°
124	116	100.0°	100.5°	122	110	80	64	86.2°	84.8°	83.9°	81.6°
112	116	99.4°	99.6°	110	102	82	54	84.6°	84.4°	83.1°	82.2°
84	116	100.0°	99.0°	142	102	70	54	88.4°	84.4°	85.9°	82.2°
Avg. 104	103	99.6°	99.6°	124	116	85	75	86.5°	84.3°	84.6°	80.4°

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
Noon..	79.1°	72.2°
Afternoon	78.1°	74.2°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Noon	114 seconds	37 seconds	56 seconds
Afternoon	114 seconds	37 seconds	54 seconds

TABLE XIII.—NINETEEN MEN UNLOADING STEEL RAILS.

Pulse Rate.		Rectal Temperature.		Blood Pressure.				Skin-Shirt Temperature.			
				Systolic.		Diastolic.		Dry Bulb.		Wet Bulb.	
Morning.	Afternoon.	Morning. F.	Afternoon. F.	Morning. mm.	Afternoon. mm.	Morning. mm.	Afternoon. mm.	Morning. F.	Afternoon. F.	Morning. F.	Afternoon. F.
100	72	99.8°	99.6°	114	104	60	50	86.0°	86.2°	82.6°	77.4°
100	96	99.7°	98.6°	138	102	86	74	86.9°	86.2°	82.0°	77.0°
96	102	99.9°	99.3°	132	104	90	65	85.1°	86.4°	80.4°	82.4°
76	76	99.6°	98.8°	132	130	90	100	85.1°	89.4°	77.6°	81.8°
104	80	98.8°	99.2°	140	110	100	80	86.2°	90.5°	78.6°	81.8°
100	96	99.1°	99.0°	146	139	105	106	86.6°	88.7°	81.1°	79.5°
92	84	99.3°	99.3°	118	108	80	60	85.7°	89.0°	78.2°	82.8°
88	88	99.1°	99.6°	140	104	95	78	84.4°	87.1°	77.0°	78.4°
80	80	99.5°	99.7°	120	128	90	90	85.7°	86.4°	76.6°	76.4°
100	88	98.6°	99.6°	115	104	70	78	84.6°	87.1°	79.0°	78.4°
64	64	99.9°	99.8°	114	126	110	110	85.1°	86.4°	82.6°	84.4°
92	88	100.7°	100.7°	152	128	100	95	86.9°	88.0°	81.1°	80.4°
80	84	99.7°	98.6°	122	122	80	70	86.8°	88.6°	81.5°	82.2°
80	84	99.2°	99.9°	123	98	60	52	88.4°	88.7°	81.3°	81.8°
72	84	98.4°	99.7°	174	166	106	94	86.0°	87.3°	79.4°	80.8°
80	76	98.6°	99.5°	112	122	70	80	86.4°	89.8°	78.8°	85.5°
100	104	98.7°	99.6°	124	130	90	102	85.1°	89.4°	80.2°	85.1°
100	112	100.2°	99.5°	110	94	74	50	86.0°	89.8°	79.0°	82.4°
80	64	99.3°	98.6°	138	102	90	60	84.8°	87.3°	77.9°	80.4°
Avg. 89	86	99.4°	99.4°	130	117	81	79	85.9°	88.0°	79.7°	80.9°

Average Air Temperature.

	Dry Bulb. F.	Wet Bulb. F.
Morning	82.2°	71.0°
Afternoon	83.6°	73.4°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning.	172 seconds	47 seconds	68 seconds
Afternoon	233 seconds	56 seconds	83 seconds

TABLE XIV.—FROZEN MEAT SHIP (NINETEEN MEN).

Pulse Rate.			Rectal Temperature.			Blood Pressure.						Skin-Shirt Temperature.					
						Systolic.			Diastolic.			Dry Bulb.			Wet Bulb.		
Morn.	Noon.	A'noon.	Morn. F.	Noon. F.	A'noon. F.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. mm.	Noon. mm.	A'noon. mm.	Morn. F.	Noon. F.	A'noon. F.	Morn. F.	Noon. F.	A'noon. F.
96	96	76	99.9°	99.9°	99.4°	160	124	142	100	90	120	66.2°	61.2°	71.2°	56.4°	56.8°	61.2°
92	96	100	99.9°	99.9°	99.8°	126	100	80	60	60	50	62.8°	68.2°	64.6°	56.8°	61.0°	62.0°
100	88	96	99.8°	99.2°	99.3°	109	108	116	48	70	80	71.8°	70.0°	72.0°	60.6°	63.0°	62.4°
80	92	88	100.1°	99.0°	98.4°	129	164	158	94	120	120	71.4°	66.0°	68.4°	68.0°	59.2°	62.6°
80	60	114	100.5°	99.6°	100.5°	102	90	98	86	40	64	79.0°	64.4°	66.6°	68.5°	60.3°	62.8°
100	96	96	100.5°	100.3°	99.9°	150	134	142	110	100	100	72.7°	66.2°	68.2°	67.6°	59.2°	62.4°
72	84	72	99.9°	98.6°	99.2°	110	140	106	47	108	60	72.1°	73.8°	70.4°	67.8°	71.2°	65.3°
100	76	100	99.3°	99.5°	100.5°	104	124	124	60	100	90	71.8°	71.4°	68.2°	62.2°	63.3°	59.8°
92	96	104	100.5°	100.5°	100.6°	104	112	118	70	80	80	74.3°	66.8°	66.4°	63.5°	59.9°	58.6°
88	88	84	99.9°	98.6°	99.0°	132	100	90	80	50	54	70.0°	71.4°	69.4°	60.6°	62.8°	63.9°
92	92	112	99.9°	100.6°	100.2°	122	118	124	100	98	80	55.6°	50.2°	59.2°	50.0°	50.0°	55.6°
100	108	88	99.3°	100.5°	99.1°	106	120	140	65	60	98	64.4°	61.2°	57.2°	57.9°	60.3°	53.8°
60	66	64	99.0°	100.6°	100.1°	110	110	97	75	85	70	67.6°	67.8°	62.0°	69.3°	64.8°	59.4°
82	88	88	100.3°	99.2°	100.2°	130	120	104	85	90	72	53.8°	70.2°	68.6°	52.0°	65.5°	61.0°
72	68	68	100.1°	100.2°	100.4°	132	142	107	100	104	40	70.7°	63.0°	68.2°	60.8°	58.6°	65.8°
76	84	96	99.1°	99.0°	99.1°	100	82	120	64	58	88	55.6°	62.8°	64.8°	53.2°	61.2°	60.1°
96	100	92	100.2°	100.5°	99.4°	168	144	138	130	110	108	62.1°	59.4°	70.5°	59.0°	57.9°	66.4°
102	80	72	99.9°	100.2°	99.4°	130	132	103	106	100	70	66.4°	68.5°	72.9°	58.4°	66.0°	68.2°
102	104	104	99.9°	99.8°	99.3°	94	93	100	44	65	70	66.4°	66.4°	74.9°	58.4°	61.0°	73.4°
Av. 88	87	90	99.9°	99.8°	99.7°	122	119	117	80	84	79	66.0°	65.8°	67.6°	60.6°	61.2°	62.4°

Average Air Temperature.

	Dry Bulb. F.
orning	33.3°
oon	29.0°
fternoon	29.6°

Average Katathermometer Readings.

	Dry Bulb.	Wet Bulb.	
	110°-100° F.	110°-100° F.	100°-90° F.
Morning.	67 seconds	32 seconds	40 seconds
Noon	59 seconds	33 seconds	38 seconds
Afternoon	51 seconds	35 seconds	38 seconds

the degree of fall did not seem dependent on the degree of heat; during the rest of the day the blood pressure remained at about the same level. The diastolic blood pressure in general followed the same course as the systolic blood pressure.

It is of interest to point out that rectal temperature and blood pressure of the men working at a temperature slightly below freezing point did not vary considerably from those of men working at a wet bulb of between 22.2° and 23.8° C..

Summary.

An inquiry into certain of the physiological functions of wharf labourers in Townsville proved that there is a general tendency for the rectal temperature to rise and remain at a higher level with higher wet bulb readings; it is, however, noteworthy that even when the wet bulb temperature reached 30° C., the averages for rectal temperatures were only betwen 37.7° and 38.3° C., with a maximum of 38.8° and a minimum of 37.5° C.. The heat regulating mechanism of the labourer was not severely affected and he was still able to maintain a temperature equilibrium, although at a somewhat higher level.

The average pulse rate did not show constant variations, perhaps it was slightly higher on hot days.

The skin shirt temperature did not vary greatly, but was much lower in the men working in the freezing room.

The average systolic blood pressure did not present constant changes, although it showed a tendency to fall with the progress of the day, concomitant with profuse sweating. The diastolic blood pressure followed closely the course of the systolic pressure.

Conclusions.

These observations carried out on a large scale prove that under conditions such as prevail on the wharf in Townsville the heat does not affect in a constant manner the men working either in the hold of ships or on the wharf in the sun as far as pulse rate and blood pressure is concerned, but only causes a slight rise in rectal temperature and perhaps in pulse rate, which roughly varies with the level of the wet bulb reading.

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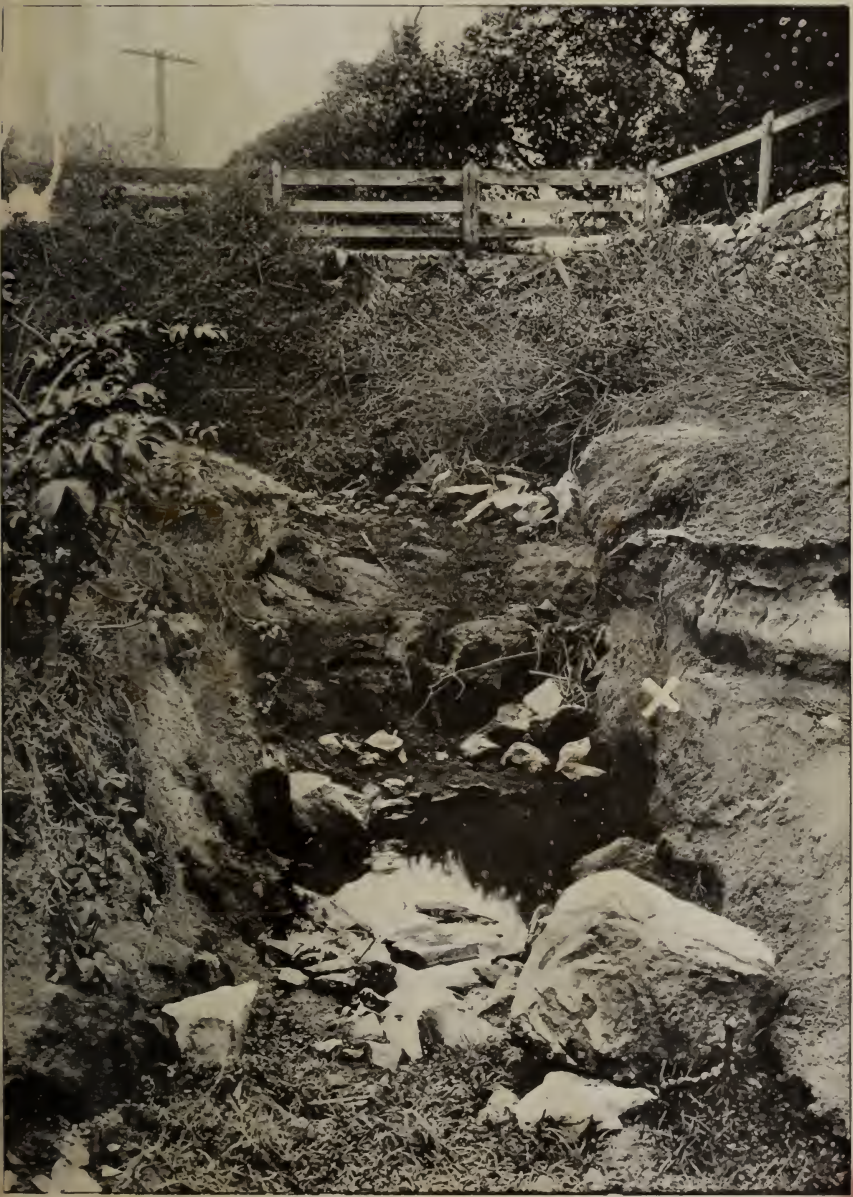

Rock-hole (Locality No. 1), showing spot upon which eggs of *Tabanus aprepes*, Tayl., were laid (marked with a cross).

THE BIONOMICS OF *TABANUS APREPES*, AND OTHER AUSTRALIAN TABANIDAE.

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(Plates I and II.)

During recent years the number of described species of Australian Tabanidae, or March-flies, as they are almost universally called in this country, has been increased very considerably, and with this increase there has come a wider knowledge of the distribution of the various genera and species. While advancement has taken place in this direction, little progress appears to have been made towards acquiring an accurate knowledge of the life-history and habits of any of these flies, and, up to the present time, no precise information has been published concerning oviposition, larval development, feeding habits and pupation of any of our numerous species.

In this paper I propose to describe in some detail the life-history, habits and developmental stages of *Tabanus aprepes*, Taylor, and *T. rufinotatus*, Bigot, which have been reared from egg to adult, and to discuss other species so far as present knowledge permits.

Tabanus aprepes, Tayl.

T. aprepes, Taylor, Proc. Linn. Soc. N.S.W. xliv, p. 56.

T. batchelori, Taylor, *loc. cit.* p. 58.

Distribution. This species is recorded from South Queensland (Eidsvold), North Queensland (Townsville and Kuranda), and the Northern Territory (Darwin and Batchelor).

Breeding-places. The following notes are based on observations made during the period 18th October 1919 to September 1920, in three localities within the municipal boundaries of Townsville, namely, (1) a small permanent rock-hole and stream arising from it, situated within half a mile of the Institute building, (2) a small shallow swamp about 250 yards distant from the rock-hole, and (3) a group of similar swamps on the outskirts of the town.

During the wet season and for some months afterwards the rock-hole and adjoining pools and riffles (Plates I and II, fig. i.) are completely swept by a rapid torrent of surface and soakage water from adjacent land; but later, when the flow is reduced to a regular and steady trickle, there is present a plentiful supply of algal growth and three or four feet of clear water in the rock-hole and rather less in the pools. From June to December 1919 the moist banks were searched unsuccessfully for larvae and pupae resulting from eggs deposited during the previous summer. On 10th October 1919 and later, Tabanidae were occasionally seen flying about, or momentarily resting upon the heads of children playing on the sea beach distant about 300 yards from the rock-hole—then the only locality within a mile or more from which they could have emerged. The species could not be determined with certainty, but was provisionally referred to *T. aprepes*.

More frequent visits were now paid to the locality in the hope of definitely associating with it the flies occasionally noticed in the vicinity. Digging operations were undertaken wherever the soil was sufficiently moist or loose enough to permit of the mergence of the flies from the ground; then the harder and drier parts of the bank and neighbouring soil were dug over and sifted, the rocks and herbage overhanging he water were searched frequently for ovipositing females or their eggs, and a few horses and cows which drank at the lower pools were watched, but no evidence of TABANIDAE could be found until 6th January, or two days after the first heavy fall of rain (106 points) since the preceding March.

On 6th January a female *T. aprepes* was observed on a twig about four and a half feet over the water (Plate I), apparently about to oviposit, when she was disturbed by a spider and flew off.

On 13th January three egg-masses were found on the same twig, all of which appeared to have hatched, but on removal to the laboratory three living larvae were rescued from a spider's web which enveloped one end of one mass. Although there appeared to be no unhatched eggs in the masses, the latter were placed over water, and during the night 110 larvae were produced, some of which were subsequently reared to the fly stage and identified as *T. aprepes*.

From 16th January until 16th April numerous larvae of *T. aprepes* were found in the algae floating on the surface of the water. Heavy floods swept the holes in the locality during the month of April, after which larvae were not found.

On 2nd April a female *T. aprepes* was observed to alight on the twig from which eggs were taken on the 13th January, and the process of oviposition was observed, with the aid of a magnifying glass, from commencement to conclusion, when the fly was captured and the eggs removed to the laboratory, where larvae were subsequently reared.

Of the 39 egg-masses collected here (Locality 1) between 13th January and 9th April, five were found on twigs and six on grass leaves or seed-heads overhanging water in the rock-hole (Plate I), the majority being from 3 to 4½ feet above the surface; three were found on grass leaves a few inches above the water trickling from the rock-hole, and 25 on the terminal shoots of couch-grass overhanging a sloping bank (Plate II), the surface of which was oozing with soakage water and algal growth.

The adjacent swamp (Locality 2) dried early in July 1919, and remained in this condition until 4th January 1920. Towards the end of April 1920 the surface area reached its maximum, there being then about 4½ feet of water in the deepest parts. Repeated searches were made for egg-masses on plants overhanging the margin and on lily and other leaves floating on the surface, but none were found. During these searches numerous half-grown to full-grown larvae (*T. aprepes*) were found clinging to the lower surface of the lily leaves, or to the stems, or hidden in floating masses of algae, from 20 to 30 yards from the margin and in from 3½ to 4½ feet of water. A few of these larvae were bred to maturity to confirm identifications.

The small lily-pond (Locality 3, Plate II, fig. 2) dried late in July 1919, and remained so until 4th January 1920. In May of 1919, when the water was two or three feet deep, a careful search was made for Tabanid larvae amongst the reeds and water-lilies, but none were found.

From 10th June 1919 onwards, the banks of this and adjoining ponds were examined from time to time as they dried, but in none of them were the larvae or pupae of *T. aprepes* found, although other species were taken.

From January 9th to April 16th 1920, when the ponds and swamps contained water, egg-masses and larvae were unsuccessfully sought for on many occasions. On the latter date a careful search was made of the vegetation growing near the banks and of the lily leaves in deeper water (4–5 feet) with the result that many larvae of *T. aprepes*, in all stages of development, were captured. On the same date a fly of this species was observed ovipositing (1.45 p.m.) on the underside of a seed capsule of a plant growing in eight inches of water and twelve inches from the bank. When about 30 eggs had been laid, a lamp chimney, closed at one end with mosquito netting, was slipped over fly and plant and tightly plugged with wadding. The stem was then cut off about an inch below the wadding plug, leaving the fly and eggs practically undisturbed. In this position the chimney and its contents were returned to the water and overhanging plants. Several times during the next hour the fly appeared to be on the point of continuing oviposition, but each time returned to the netting without having extruded any eggs.

Between 21st and 25th April very heavy falls of rain and high winds caused an accumulation of drift (grass, aquatic plants, twigs, cow and horse dung, etc.) to be thrown up on the sloping banks of this and adjacent pools. When examined on 28th April, numerous half-grown to full-grown larvae of *T. aprepes*, *T. rufinotatus* and *T. nigritarsis* were found in the drift and on or under the soil beneath it; while others were found buried in the grass-covered soil between the outer fringe of the drift and the foot of a stiff loamy bank three or four feet from it (Plate II, fig. 2). The latter were full-grown and were in some cases obviously at rest in the positions in which they intended to pass through the long dry period to follow; in others they were still burrowing downward. Quite a number of those found in the drift, and especially in that part near the water's edge, were evidently feeding, as shown by the contents of the alimentary tract. Many of these larvae (*T. aprepes*) were captured and bred out in the laboratory in July and August.

While turning over the soil and drift on this date several recently discarded pupal cases were found and subsequently identified as those of *T. rufinotatus* and *T. nigritarsis*. These pupae were almost certainly the product of eggs laid more than a year earlier, since the unusual conditions of the 1919–20 season and the shortness of the possible breeding period (103 days) almost preclude the possibility of their being derived from eggs laid during the current year. No definite evidence has been obtained to determine the maximum period during which the larvae of these insects may remain in a dormant condition, but certain facts suggest that full-grown larvae may, after the usual long resting period and in the face of a drought, postpone their transformation into pupae for six months or more.

On the same date (28.iv.1920) and a few yards distant, full-grown larvae of *T. aprepes* were found making their way up a slope from the water's edge, through short wet grass and litter towards a bank (similar to that shown in Plate II, fig. 2) and about eight feet from the water's edge. Some were actually travelling when observed, others were sheltering in the grass or under debris.

These banks were examined four months later (30th August), when several *T. aprepes* (three pupae and five larvae) were found, and on the same afternoon an adult female was captured in the vicinity. The period (winter) intervening between these dates, 28th April–30th August, had been unusually mild and moist, doubtless favouring early development and rendering the emergence of the adults possible after even a light shower of rain. During the preceding year, owing to drought conditions, emergence of adult flies from this soil would have been a physical impossibility throughout the whole period April 1919 to January 1920.

Oviposition. In discussing breeding-places brief reference has been made to two flies which were observed in the act of ovipositing on 2nd and 16th April. As the process differed in several respects from that recorded for Indian and American species, it may be of interest to refer to it more fully here. At about 4.30 p.m. on 2nd April, whilst sitting by the water's edge (Locality 1), a fly was seen to alight on the underside of a twig about four feet above the surface of the pool (Plate I) and about three feet from my head. The twig lay at an angle of about 45° to the water, and the fly settled on it *head uppermost*. After lightly touching the surface of the twig many times with the tip of the abdomen, the first egg was extruded whilst only the extreme apex of the abdomen was flexed. Immediately the apex of the egg touched the twig it appeared to stick, and as it left the body it was forced out of the vertical position to an angle of about 20°; the apex of the abdomen was again applied to the twig at the point of attachment and to one side of the egg just laid and a second extruded in the same manner. Three eggs were then laid close to and in front of the first two, each one as it left the ovipositor being pressed firmly against those behind, until the latter lay almost parallel to the twig. In this way three or four gradually widening rows were laid, each slightly nearer vertical than the preceding one. Then a second and similar tier was commenced on top of those already laid, the first row of eggs of the second tier resting on the second or third row of the lower tier. Moving her body slightly forward, the fly extended the lower tier two or three rows before continuing the upper tier. In this way the operation was continued until the mass had covered the lower side of the twig for a length of 30 mm., when the fly moved forward a few millimetres and remained stationary until captured. The rate of oviposition was about three eggs a minute, and at no time was the apex of the abdomen brought *under the thorax*, as stated by writers dealing with extra-Australian species.

The Egg-mass. The size and shape of the egg-masses are very variable. As a rule they are about 20–33 mm. long by about 2 mm. wide when deposited on slender twigs or narrow blades of grass, or they may be more compact when laid on seed-heads or other objects offering a wider base for the mass. The mass is invariably as wide as the object upon which it rests and generally contains two layers of eggs. Some of the masses, however, contain three layers of eggs and are proportionately shorter and higher. Sometimes a second and even third mass is laid very near to or overlapping part of an earlier one, and small masses containing only a few score of eggs are found near masses of average size. The number of eggs per mass probably averages about 500, but much smaller and much larger masses, *i.e.*, 250–700, are found. At first the mass is creamy, but in the course of about 24 hours it changes to light slate-purple, and gradually darkens with the development of the larvae. There is a complete absence of the white chalky substance used by some species as an outer coating of the mass, and more often than not its general appearance is distinctly rough and lacking finish.

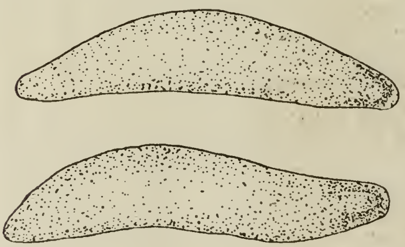

Fig. 1. *Tabanus aprepes*, Tayl., eggs.

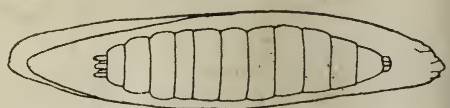

Fig. 2. *T. aprepes*, embryo 78 hours old.

The Egg. The eggs measure 1·60 mm. to 1·65 mm. in length, by 0·3 mm. in width, and are variable in shape according to their position in the mass, but always bluntly rounded at either end (fig. 1). The surface is smooth and glossy and, in recently laid eggs, pearly white. The colour changes rapidly ; eggs that were laid at 1.50 p.m. on 16th April changed to grey by 5.15 p.m., to dark slate-purple by 9.30 a.m. on 18th, and hatched during the night of 22nd or early morning of 23rd. Another batch of eggs which was laid at 4.30 p.m. on 2nd April changed to dark slate-purple by 9.30 a.m. on 4th and hatched between 2 and 4 p.m. on 8th. The egg period therefore was from six and a quarter days to seven days in the one case and about six days in the other.

For at least 24 hours before the young larvae hatch they are distinctly visible through the clear, thin shell (fig. 2). During this period they are active, dark-banded little creatures, with the head always directed outwards from the point of attachment of the egg-mass. When about to liberate themselves the blade-like process (egg-cutter) at the anterior end is pressed against the apex and drawn downwards along the side in two or three deliberate strokes, which cause a rent in the shell sufficiently large to permit the young larva to escape rapidly.

Larval Development. Generally speaking, there is only an interval of a few minutes between the appearance of the first and last larvae from a given batch of eggs. Sometimes, however, the interval is much longer, and this is especially the case with large masses, in which, owing to their form, many of the eggs are concealed beneath tiers of other eggs. One large mass from which all the larvae had apparently emerged before noon (13th January) produced 110 additional larvae before 9 a.m. on the following morning; another produced about 600 larvae during the morning and 30 more late in the afternoon.

In only one instance (5th April) was the dispersal of larvae observed under natural conditions. On this occasion several very small larvae were gathered on the surface of the pool (Plate I) in one dip of the scoop while searching for *Anopheles*, and upon examining some twigs overhead an egg-mass was found from which larvae were then dropping. The mass contained approximately 300 eggs, arranged in a single layer eight or ten abreast, of which number about one-third had already hatched and dropped into the water; the balance emerged during the succeeding five or six minutes. Upon reaching the water the young larvae were rather sluggish, but sufficiently active to disperse by slow lashing movements, some remaining on the surface film, others seeking the shelter of floating masses of algae. Some of these larvae were collected and removed to the laboratory for examination and observation.

In the laboratory the egg-masses were usually suspended over a shallow dish of clean water, into which the young larvae dropped as they freed themselves from the mass. For some hours they remained more or less quiescent on the surface, during which period the first moult was accomplished. This process commences before, or immediately after, the young larvae leave the egg, and is sufficiently advanced to be seen under a low power five minutes later. Apparently the first moult is always completed during the first six hours of larval life. As a number of larvae from one egg-mass have been reared through all their stages to the perfect fly, the development of these may be now recorded. While this batch was under observation a number of other batches were available for study, and they supplied much information and material for examination which could not have been obtained from the constantly decreasing ranks of the original batch.

The egg-mass from which the larvae were obtained was found partly evacuated on 13th January (Locality 1); 110 young larvae emerged from it on the afternoon and night of 13th–14th January and 105 of these comprised the original batch.

First Instar. An accurate description of the young larva soon after it emerges from the egg is somewhat difficult, owing to the fact that ecdysis has already commenced. When about five minutes old and after fixation in the usual way the young larva measures about 1·40 mm. long by 0·28 mm. wide at the sixth segment; the segments appear to be withdrawn into each other; the cuticle about to be cast off envelopes the body loosely, excepting at the head, where it is firmly attached. The surface is pale in colour and distinctly marked with longitudinal striae; several moderately long slender hairs are present about the middle of each segment; there are no short spine-like hairs fringing the anterior margin of the first three segments (thoracic), such as occur on the fourth segment and in increasing numbers on the fifth to the tenth segments. The anterior margin of the first two segments and the anterior and posterior margins of the following seven segments appear to be banded, but this appearance is due to characters on the cuticle beneath. The mandibles are withdrawn into the head, but in cleared specimens they are seen to be short, curved rods arising apparently in the anterior third of the first segment. The egg-breaker is a black, chitinous, angular projection of the upper anterior margin of the labrum and is the most conspicuous feature of the first instar. Graber's organ is visible on the posterior portion of the tenth segment as a pair of dark, pyriform, closely approximated bodies.

Second Instar. Since most of the characters found in the larvae of the second instar are visible through the cuticle of, and appear to belong to, the first instar, the changes which follow the first ecdysis do not appear to be so great as they are in reality. Fixation in hot alcohol after the first ecdysis is completed and in all subsequent stages of larval development has the usual effect of extending the body to its fullest length ; thus, whereas the length of a larva of the first instar is about 1·40 mm., the length just after moulting is about 1·00 mm. greater. The measurements, descriptions and figures which follow are all from specimens fixed in hot 70 per cent. alcohol, and therefore fully extended. The characters of the larvae of the second instar are shown in fig. 3, which represents a larva between one and six hours old. Such larvae range from 2·35 mm. to 2·63 mm. in length, by 0·375 mm. to 0·425 mm. in width at the widest part ; the segments bear distinct longitudinal striae ; the anterior border of each segment, excepting the first three (thoracic), is fringed with numerous small bristle-like hairs and dense short brown pile, which produce the banded effect (segments four to nine inclusive resemble the tenth segment shown in fig. 3). The first three (thoracic) segments are shown in fig. 3. The mouth-parts are prominent ; the first maxillae, palpi, and antennae are easily distinguished ; the anterior projection of the labrum is rounded and no longer black and chitinous ; four malpighian tubes are distinguishable ; Graber's organ still contains one pair of bodies, which are now seen to be enclosed in a pyriform sac, the rounded end of which is foremost ; the apical third of the syphon tube bears two groups of three long slender hairs, which usually appear to arise at the extremity owing to invagination of the apex and withdrawal of the stigmal plate.

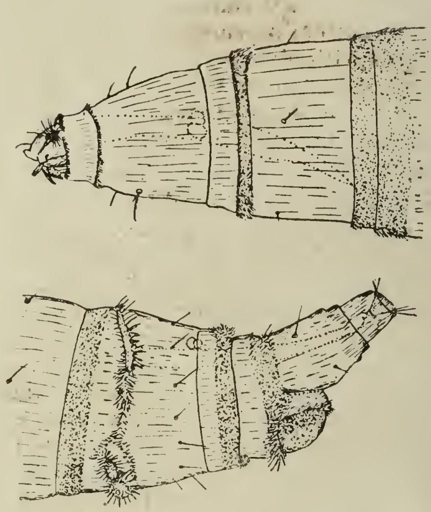

Fig. 3. *T. aprepes*, anterior end of larva 1–6 hours old (above) ; posterior end of same (below).

During the 16 or 17 hours following the first ecdysis there is little apparent change in the young larva other than a slight increase in size and, generally, the addition of another pair of bodies in Graber's organ. A long series of larvae of this age measured from 2·35 mm. to 2·82 mm. in length, by 0·35 mm. to 0·425 mm. at the widest part.

For about three days following their emergence the young larvae do not feed, but remain on the surface film. After this period, however, they commence to attack each other, even in the presence of an abundant supply of small shells and other animal life introduced upon aquatic plants.

When twelve to fourteen days old the majority of the larvae measured from 6 mm. to 7 mm. in length, by 0·7 mm. to 0·85 mm. in width ; the groups of hairs on the syphon tube increased to four or five, and Graber's organ contained either two or three pairs of bodies, each pair diminishing in size from the anterior end. A few of the larvae had developed very slowly during these twelve days and now measured only 4·5 mm. in length. In two larvae (7 mm. and 8·5 mm. in length respectively) a second pair of mandibles could be distinguished in the anterior third of the first segment, and faint traces of the dark bands characteristic of older larvae of this species could be detected near the junction of the segments and near the anal protuberance. The second ecdysis apparently takes place when the larva is between 7 mm. and 9 mm. in length. Unfortunately the number of larvae in this batch became so reduced, largely owing to cannibal practices, that specimens could not be secured as frequently as desired to determine this point, but a " wild " larva captured on 2nd March appeared to represent an early stage of the third instar and to connect the last-described individuals with older and more advanced ones of the same batch. This larva measured 9 mm. in length by 1·5 mm. at the widest part ; the junctions of the segments were banded and blotched with dark brown, and the dorsal tubercles and the pseudopods bore short bristle-like hairs, as in older larvae.

On 2nd March, or when 49 days old, two larvae of the original batch measured 15 mm. and 16 mm. in length respectively. Whether the subsequent changes in the larvae follow ecdyses, or whether they are developed gradually during the third instar, has not yet been satisfactorily determined. On 16th April, or when 94 days old, two other larvae of this batch were destroyed by their fellows. The former now measured 21·5 and 24 mm. long by 3 and 4 mm. wide respectively. The brown bands and blotches are now very distinct and of the same pattern as in adult larvae ; the striae are well marked on all segments, but are absent on the brown areas ; the mandibles are black ; the bunches of stout curved spines above the insertion of the antennae are pale ferruginous, very prominent, and overhang what appear to be moderately large facetted eyes situated behind them ; in the smaller of the two larvae there are five pair of bodies in Graber's organ, in the larger six pairs ; the stigmal plate is now visible at the apex of the syphon tube. About the anterior third of the first segment (prothoracic) there are several long branched hairs, on other segments they are simple or absent ; the pseudopods are prominent ; there are no hairs on the anterior margin of the thoracic segments, these being confined to the dorsal ridges and pseudopods of the abdominal segments, where they are inconspicuous. The dark bands and blotches are formed entirely of very short and dense pile, as in the younger larvae ; the pseudopods were very prominent in the larger of the two larvae.

On the same date (16th April) the contents of the breeding-tray were collected, with the object of separating the remaining larvae of *T. aprepes* and several larvae of *T. nigritarsis* which had been placed in the tray recently. The former now numbered only five, two of which measured about 28 mm. long and three about 33 mm. long. One of the latter was retained for examination and is described below, the others were put separately into five-inch flower-pots half full of moist, clean granite sand, upon which lily leaves and shells were placed every three or four days. The larva referred to above was 94 days old at the time of its death, and measured 33 mm. in length and 5 mm. in width. In size and coloration, as well as in external form, it so closely resembles the mature larva which has undergone a long resting period that a description of it will suffice for both. There are six prominent pseudopods to each segment from the fourth to the tenth inclusive, arranged on the anterior margin, three on each side of the median line ; each pseudopod is armed with a number of short bristle-like hairs ; on the dorsal surface of the same segments there are two transverse tubercles situated on the anterior margin on either side of the median line, which appear to be of the same nature as the pseudopods and similarly armed. The dorsal surface is blotched and banded boldly with dark brown (fig. 5), the pattern of which is very characteristic and constant. The ventral surface of segments four to nine inclusive are creamy white; from the dark anterior margin of the first segment (prothoracic) there extend posteriorly five dark, lanceolate marks, one on either side of the dorsal and ventral surfaces, and one in the median line of the ventral surface. The second and third segments are banded anteriorly (fig. 6) and the tenth posteriorly (fig. 7) with brown.

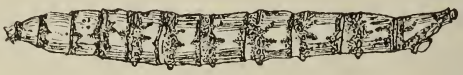

Fig. 4. *T. aprepes*, adult larva, lateral view.

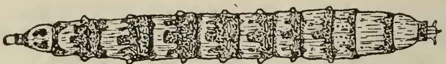

Fig. 5. *T. aprepes*, adult larva, dorsal view.

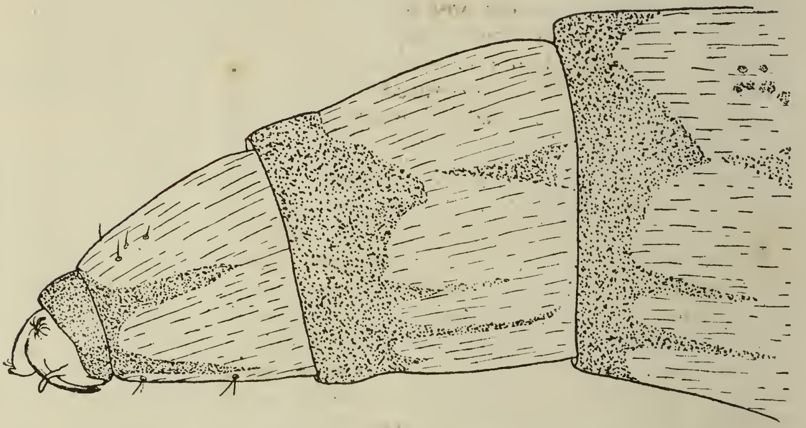

Fig. 6. *T. aprepes*, adult larva, anterior end.

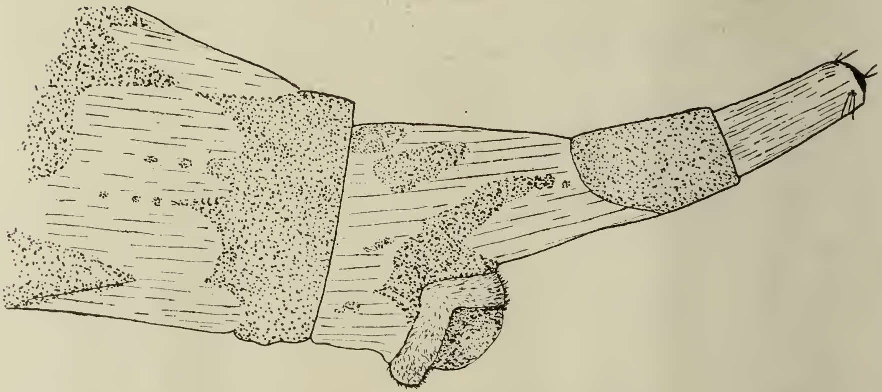

Fig. 7. *T. aprepes*, adult larva, posterior end.

As the larvae reached maturity and ceased to feed (about the third week in April) they were placed together again in a large receptacle containing moist sand, in which they remained for about two months. At first they were very active, coming to the surface at night and returning to the sand during the day, but never attacking each other. On 3rd June they were all in a torpid state and contracted to about 18 mm. in length, but when placed in water they regained their normal appearance and activity.

On 25th June one of the larvae, now 164 days old, pupated in a vertical position four inches below the surface and after a pupal period of 11 days emerged as a perfect fly (female). Another larva pupated about a week later and was preserved as a specimen; the third pupated on the 7th July and produced a male fly on 21st July, or 190 days after hatching; the fourth remained in the larval stage until 8th September (239 days), when it was destroyed for examination.

Larval Habits under Natural Conditions. Under natural conditions the larvae are to be found commonly on or near the surface of clear and moderately deep pools, amongst submerged herbage near the banks, resting upon the lower surface of lily leaves, upon the submerged stems and leaves of all kinds of aquatic plants and in floating masses of algae. Clear and moderately deep water appears to be essential. The food of the young larvae is not known, but it is believed to be the small molluscs, which were fed successfully to larvae reared in captivity. Several kinds of molluscs are very plentiful in most of the breeding-places, and these certainly form an important part of the diet of older larvae, which have frequently been found feeding on them.

In the rock-hole (Locality 1) this food is absent, but there is a plentiful supply of other kinds. Cannibalism is common amongst "wild" larvae, and is practised by individuals in all stages of development. To give some idea of the voracy of these insects, it may be mentioned that on one occasion 12 large larvae were placed in a pickle-jar of water and algae for transportation to the laboratory—a journey of three miles—and upon arrival there only two remained alive, one of which destroyed the other before arrangements could be made for their separate accommodation. On another occasion over 50 nearly full-grown larvae were placed in a large porcelain dish with sand, water and fresh molluscs. Within four days many of the latter and 40 of the larvae were destroyed.

With the aid of a small stout wire net attached to the end of a long bamboo rod the plant growth can be disturbed sufficiently to dislodge the larvae, which, even if carried down by the currents thus created, soon appear near the surface and are easily captured in the net. In some cases a stout wire hook at the other end of the rod was found useful for dragging masses of vegetation towards the bank for closer inspection. Wading was resorted to in many cases, but the results were usually unsatisfactory on account of the restricted range of vision.

The larvae appear to live entirely in water until they have reached maturity, when they migrate from the water to high ground close by, as described elsewhere in this paper, and penetrate into the soil or clay to a depth of from 7–15 cm., where they remain in the larval stage, generally with head uppermost, for several months.

The Pupa. During the first few hours following metamorphosis the entire pupa is buckthorn-brown,* but the eyes soon deepen to mummy-brown, and then to blackish brown, while the thorax becomes argus-brown. The average size is about 21 mm. in length by 4 mm. in width at the thorax, the 1st and 6th segments slightly narrower than the 2nd to 5th inclusive.

On the dorsal surface of the first abdominal segment there are two stout hairs on either side of the median line and three on each pleura, two of which arise close together near the wing-sheaths. Segments 2 to 7, inclusive of both surfaces, bear an

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* Ridgway's colour nomenclature.

uninterrupted fringe of long and short bristles arranged roughly in two rows, the shorter bristles nearer the base ; on each segment from the 2nd to 5th these bristles increase in length ; on the 5th, 6th and 7th they are equally long or, rarely, the long bristles may be absent from the middle of the seventh tergite and sternite and the shorter ones may be branched.

The six projecting spurs at the apex of the abdomen are arranged three on each lobe of a prominent bilobed tubercle divided vertically by a deep cleft, which is wider in the males ; the upper and middle pair are equally long and stout, the lower are smaller ; on either side of the dorsal surface midway between the base of the tubercle and the apex of the 7th segment there is a group of four or five stout spines of unequal length. The length and stoutness of these bristles vary greatly in individuals of either sex.

The anal tubercle is very large and deeply furrowed in the male and is bordered anteriorly by an unbroken fringe of about 18 to 22 stout bristles of variable lengths. In the female the fringe is broadly interrupted in the middle, and consists of from 6–9 bristles on either side (fig. 8).

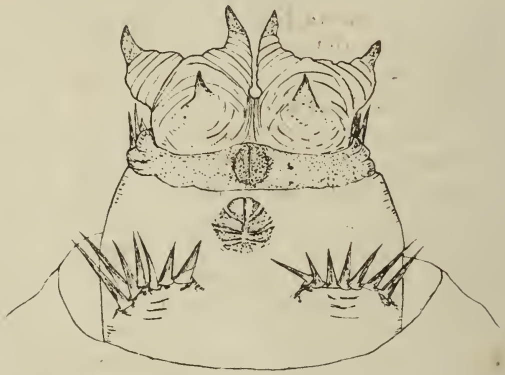

Fig. 8. *T. aprepes*, ventral surface of last segment of female pupa.

Duration of the Pupal Stage. The duration of the pupal period during the months June–September varied from 8 to 20 days, the average being 12 days in the case of 10 individuals whose periods were accurately observed.

The factors which determine early or late emergence of laboratory specimens are not known, and no explanation can be offered at present of the fact that whilst certain pupae of a batch pass through a very short pupal stage—*e.g.*, eight days—others of the same batch and subjected to the same treatment may remain in the stage for periods up to 20 days.

Emergence of the Fly. The emergence of laboratory-bred flies has been observed on several occasions—always between 10 a.m. and 4.30 p.m.—and in each the procedure was similar. The pupa, with its body vertical, works its way to the surface, from which it protrudes the thorax and first two or three abdominal segments. In this position it remains motionless for from one to two hours ; then, with very little apparent effort, the thorax is burst on the dorsal surface to the posterior margin of the mesothorax, and also along the lower margin of the eyes, leaving a flap-like piece bearing the anterior group of tubercles more or less loosely attached ventrally. The fly frees itself in a minute or two, leaving the greater part of the pupal case as before. At emergence the wings are uniformly opaque, but in the course of an hour or two they become hyaline or suffused with brown, as the case may be.

The Adult. The adults of this species show considerable variation in regard to size and coloration and, as might be expected, in laboratory-bred specimens this is more apparent than in those bred under natural conditions. In a recent paper* it has been stated that the wings show various gradations in colour from a total absence of infuscation to a very pronounced shading, especially at the veins. A long series of males and females bred out in this laboratory show these gradations to a marked degree, not only in flies reared from full-grown larvae captured in natural surroundings, but also in flies reared from the same batch of eggs. Variations in abdominal coloration of both sexes, and especially in the females, is even more pronounced. In some specimens there are evident spots at the apex of certain segments, in others the abdomen is of uniform dark brown or uniform ochraceous tawny. In three wild females captured in June in this district the colour of the abdomen is so light as to lead the writers of the above-mentioned paper to refer them with some doubt to this species. Recently, however, a similar form has been bred from a batch of eggs which also produced individuals showing all the variations of wing and abdominal coloration. It would appear that in this and other species too much attention has been paid in the past to slight or even marked differences of this kind. When these variations in colour are associated with abrasions of the abdomen and thorax, and especially of the front, the possibilities of error in diagnosis are greatly increased unless a fairly long series is available for comparison.

In life the lower third and the lateral and posterior margin of the eyes of the male are claret-brown with emerald-green iridescence ; the upper two-thirds are drab grey and composed of coarse facets. In the female the facets are small throughout and the colour uniform drab grey with brown iridescence.

Seasonal Occurrence. Throughout Australia, perhaps excepting the wet belts of the North Queensland coast, of which I have little knowledge, there is a marked seasonal occurrence of flies of this family, namely from about October to April. In the southern regions, where there are regular winter rains and low winter temperatures, the emergence of flies is probably regulated by temperature and not by rainfall ; but in the north, where the temperature is more or less equable and the rainfall is, excepting for moderate falls, confined to the summer months above mentioned, the condition of the soil, whether dry or wet, is most certainly the regulating factor. Thus almost invariably the march-fly season is either early or late, good or bad (from the collector's point of view) according to whether the summer rain is early or late and normally heavy, light or absent.

The chief natural breeding-places in this district, and in most others with which I am familiar, are in temporary accumulations of water, such as shallow swamps, which disappear completely in the winter or dry season and after the full-grown larvae have entered the soil in the vicinity of the water's edge, wherever that may be at the time of their reaching maturity. As the soil dries these larvae are practically immobilised, and remain so until it again becomes thoroughly moistened. It follows, then, that there can be no emergence of flies until after heavy rain has fallen.

The truth of these statements has been demonstrated on many occasions, and notably during the summer of 1919–20, when until 4th January the country was in the grip of a severe drought, and there was an almost complete absence of Tabanids in this district. Heavy rains for a short period in this month were followed by the appearance of a moderate infestation of flies. (It may be stated here that the previous season also was one of unusually low rainfall, and therefore an unfavourable one for fly breeding.) The January rainfall was not sufficiently heavy to raise the level of the swamps to normal, and another long spell of dry weather intervened before the banks in the vicinity of the normal high-water marks were thoroughly saturated. About the middle of April abundant rains filled the swamps, and there followed a marked increase in the number of flies in the district. Whether the flies were derived from eggs laid in January 1920 or during the preceding wet season could not be determined, but the period required for the life-cycle, as ascertained later, suggests strongly that the latter was more probable. Further, there is no evidence to suggest that the Tabanids in this or other districts known to me produce two generations in one season. Obviously these remarks do not apply to localities in which there is permanent surface water, such as Locality No. 1.

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* Ferguson & Hill, in the press (Proc. Linn. Soc. N.S. Wales).

In some localities a few individuals of certain species, particularly *T. rufinotatus*, are to be found throughout the dry season (June to August), but their occurrence can be accounted for by the presence of permanent water (such as Locality No. 1), or at any rate marshland, in the vicinity.

During June of this year numerous young larvae were found in pools which dried a few weeks later. The question naturally arises whether these larvae perish or whether they are able to burrow into the mud to lie dormant through the remainder of the dry season and until conditions again become favourable for their development. Attempts to determine these questions have been unsuccessful, but it may be mentioned that one larva from a late batch of eggs was, when about 9 mm. long, accidentally isolated in the laboratory in a pot of dry sand and without food of any kind from about 6th June to 28th August. On the latter date it had the general appearance of adult larvae in the resting stage preceding pupation, and became active immediately it was placed in water containing suitable food and cover. Unfortunately neglect caused its death before any development could be detected. Hine, working in America, found that certain Tabanid larvae after a long resting period again fed before pupating, but nothing of the kind has been observed to take place in the case of any of the species studied here.

Rearing Larvae in Captivity. Various methods of rearing the young larvae were tried, but as none of them gave satisfactory results it is not intended to describe them in detail. In order to prevent cannibalism young larvae were isolated in small earthenware pots with a capacity of about 120 c.c., prepared in various ways, and supplied with various kinds of food. Apart from the difficulty of keeping the water in these vessels fresh, this method was found to be too cumbersome, and the larvae rarely survived for more than a week or so. Larger vessels, *i.e.*, five-inch flower-pots and small museum jars, were equally unsatisfactory. Kerosene tins cut lengthwise into two equal parts gave better results, and in them a few larvae were reared from the egg to maturity. These tins were prepared by placing a quantity of clean sand at one end and two or three inches of water at the other. Pieces of water-lily leaves, algae and swamp plants carrying small molluscs were placed in the water to afford shelter and food, and these were renewed as often as possible. The water was changed every four or five days by lifting one end of the tin and allowing it to filter through the sand. The tin was then partly filled and again emptied in this way, before being finally replenished with water and food-bearing vegetation. Each tin contained the progeny from one batch of eggs, *i.e.*, 300–600 larvae, of which never more than 1–2 per cent. reached the imago stage. When molluscs were not obtainable mosquito larvae and small earthworms were offered as substitutes, but worms were invariably refused by larvae in all stages of their development. Mosquito larvae were destroyed by the Tabanids when the former were stranded in algae or sand, but otherwise they appeared to have been able to avoid capture. At all times Tabanids of this species appear to feed upon their fellows in preference to molluscs or any other animals, and for this reason it was found best to transfer the survivors, when of nearly full size, to separate pots or dishes, where they completed the development in moist sand, upon which molluscs and portions of lily leaves were placed. The best results were obtained from a batch of 105 larvae which were reared in a concrete trough, measuring 16 inches wide by 20 inches long by 6 inches deep, prepared similarly to the tins just referred to. As the larvae approached maturity the water was gradually reduced until it was confined to a small area at one end of the trough. In this molluscs were placed every week or so, until it was found that none were being devoured, when the water was drawn off and the trough half filled with clean sand, which was kept moist. From time to time the sand was turned over to watch the progress of development, but beyond this the larva received no attention for intervals of several weeks. Some of the larvae pupated and produced flies in this trough, but most of them were transferred to small pots of clean moist sand, where they completed their development. In future it is intended to use these large troughs or galvanized iron trays instead of the smaller vessels.

Tabanus rufinotatus, Big.

T. rufinotatus, Bigot, Mem. Soc. Zool. France, v, 1892, p. 673.

T. lineatus, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 65.

T. elestëem, Summers, Ann. Mag. Nat. Hist. (8) x, 1892, p. 224.

T. designatus, Ricardo, Res. Expéd. Sci. Néerlandaise Nouv. Guinée, ix, pt. 3, 1913, p. 390.

Distribution. This is a widely distributed species, having been recorded from South Australia, New South Wales, Queensland and the Northern Territory, and also from Dutch New Guinea. The South Australian specimens in the British Museum collection are most probably from Port Darwin (Northern Territory) or its vicinity, which prior to 1911 formed part of the state of South Australia.

Breeding-places. On 25th March 1919, an egg-mass was taken from the lower surface of a *Juncea* leaf growing three feet from the bank of a shallow water-hole (near Locality 3) in twelve inches of water. At the time the pool contained a maximum depth of three feet of water and was much frequented by cattle and horses which grazed in the district. As the season advanced the water dried back rapidly and finally disappeared before the end of May. During the period intervening between 25th March and 28th May 1919 the vegetation near the water and the muddy banks and bottom were searched for egg-masses and larvae respectively, but without success. During the same period and up to the present date (September 1920) many other possible breeding-places have been repeatedly examined, but so far only a few adult larvae have been secured.

The Egg-mass. The egg-mass referred to above, from which the larvae described in the following notes were derived, measured 5·5 mm. in length by 4·25 mm. in width at the base and 3·5 mm. in height. The eggs, which numbered about 500, were arranged very compactly in three tiers and were coated, either separately or collectively, with a white secretion. After the larvae hatched, the mass retained its form so perfectly that, viewed from any direction but from above, it appeared to be still composed of viable eggs.

Larval Development. The larvae hatched almost simultaneously at noon on 30th March and moulted between that hour and 9 a.m. on the following day. Specimens were not secured prior to ecdysis, so that the first instar cannot be described here.

The Second Instar (figs. 9, 10). When 24 hours old the larvae of the second instar measured from 2·5 mm. to 2·6 mm. in length by about 0·25 mm. in width at the widest part. Up to this age they were of uniform size, but at the end of the second day variations became apparent, some measuring 3 mm., while others had increased to 3·5 mm. The cuticle is creamy white and bears minute longitudinal striae; the tufts at the base of the antennae are short and many of the component hairs are forked; the prothoracic segment is short, and the hairs which fringe its anterior margin and the anterior margin of the next segment are difficult to discern. The dorsal tubercles and pseudopods are armed with moderately large hairs, and each segment bears several isolated long, slender, pale hairs.

The young larvae remained in a small dish of water for three days without food, when they were placed in a large concrete trough containing sand at one end and water at the other. In this they were offered small molluscs, young mosquito larvae and small aquatic animals that adhered to the water-lily leaves used to provide cover. From time to time dead larvae were found which appeared to have been destroyed by their fellows, but the remainder seemed to thrive. On 10th June, or when 77 days old, one of the larvae measured 15 mm. in length. Unfortunately this specimen was lost before a detailed description was obtained. On 3rd July the sand was allowed to dry off gradually, and from this date onwards small earthworms only were offered as food. On 8th October the sand was washed over, but no larvae were found. The vessel and its contents were left undisturbed until 27th October, when the now dry sand was sifted, yielding three larvae measuring from 22 mm. to 23 mm. in length by about 2·5 mm. in width. In such larvae the cuticle is glossy and devoid of the striae observed in larvae of the second instar, there is no trace of banding, and the hairs on the dorsal tubercles and pseudopods are colourless.

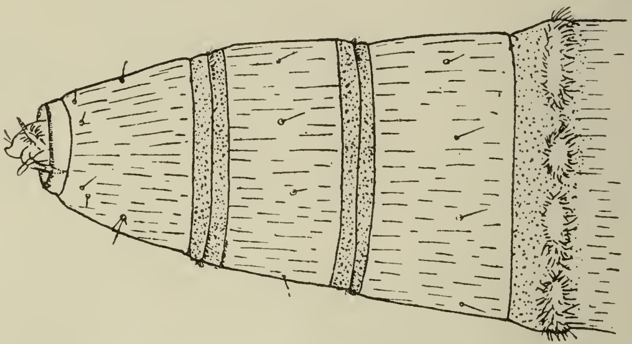

Fig. 9. *Tabanus rufinotatus*, Big., anterior end of larva 24–48 hours old.

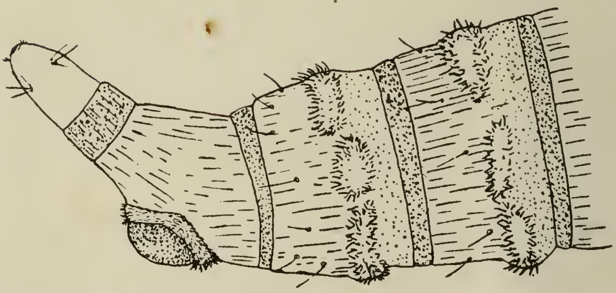

Fig. 10. *T. rufinotatus*, posterior end of larva 24–48 hours old.

The two remaining larvae were now placed in a large shallow dish, containing sand at one end and water at the other, in which they were fed on earthworms and mosquito larvae until 8th November, when they were placed separately in five-inch flower-pots standing in a dish of water and containing three inches of clean sand. On 8th December both larvae were evidently fully grown. One of these was secured for examination and is described below, the other was returned to its pot, to which had been added a few small earthworms and a little earth. A week later it was found dead and damaged beyond recognition by scores of nematode worms. The loss of the sole surviving larva rendered the identification of the species with which I had been dealing for over nine months impossible for the time being, but the larvae secured on 27th October and 8th December provided the material from which a determination was subsequently made in comparison with a series of "wild" larvae, some of which were subsequently bred out.

The Adult Larva (figs. 11, 12). The full-grown larvae measure from 26 to 29 mm. in length by about 4 mm. in width, and are creamy white in colour, with the faintest indication of darker bands; the cuticle is glabrous and without striae; the tufts at the base of the antennae are composed of short stout hairs; there are no hairs on the anterior margin of the thoracic segments, and those of the dorsal tubercles and pseudopods are very short, slender and dark in colour.

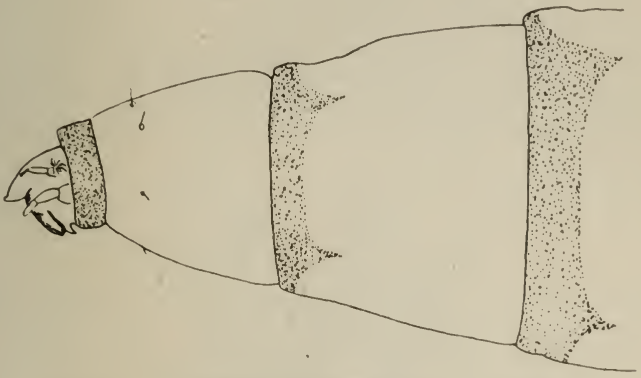

Fig. 11. *T. rufinotatus*, anterior end of adult larva.

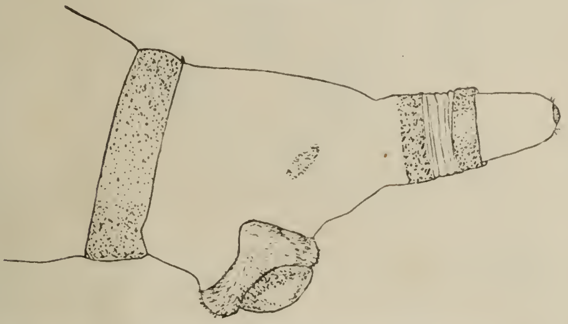

Fig. 12. *T. rufinotatus*, posterior end of adult larva.

From this record it will be seen that under laboratory conditions the larval stage was not less than eight and a half months.

Development of Larvae under Natural Conditions. Larvae were taken on 28th April 1920 in association with the larvae of *T. aprepes* and *T. nigritarsis* (see notes on *T. aprepes*), and again in a similar bank on 15th June in association with the larvae of *Silvius notatus*. After securing specimens for examination, the remainder were placed in small earthenware vessels containing sand, which were thereafter kept moist. The flies emerged as follows:—one female on 23rd May (after a pupal period of nine days), one male on 2nd June, and one female on 21st July.

The Pupa. The average length of the pupa is about 15 mm. and the width at the thorax about 4 mm. The eyes are blackish; the vertex (in the female) and thorax Dresden brown, the latter with faint traces of stripes; abdomen ochraceous tawny, with Dresden brown stripes corresponding to the black stripes on the abdomen of the imago. The first abdominal segment bears two isolated hairs on either side of the median line and one on each pleura behind the spiracle; the second to seventh tergites and pleurites each have a double row of bristles, those of the anterior row being much shorter than those of the posterior. On the ventral surface, segments 2, 3 and 4 each bear an irregular single row of bristles of varying length; on the 5th to 7th segments the bristles are arranged in two rows; the terminal segment bears the usual number of large spurs (six); anterior to the anal tubercle there is, in the male, a fringe of about twenty long straight or curved bristles, which in the female is interrupted in the middle and is composed of five to eight stout and generally straight bristles (fig. 13). In the male the anal tubercle is large and deeply ribbed, in the female it is small but prominent. On either side of the dorsal surface, midway between the base of the upper pair of spurs and the posterior margin of the 7th segment, there is a group of six or eight stout bristles of irregular size and shape, which in the female is reduced to two or three much smaller bristles; in addition, in the male, there is on either side a group of two or three very short bristles midway between the above and the posterior extremity of the anterior fringe.

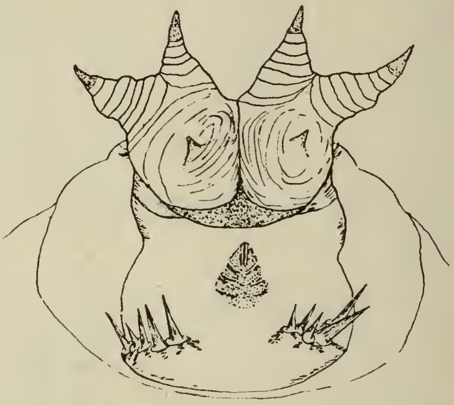

Fig. 13. *T. rufinotatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the male have the upper part grey, with deep brown iridescence, and the lower part, lateral and hind margins maroon, with an emerald-green band in line with the insertion of the antennae. The facets of the lower part are larger than those of the upper. In the female the eyes are maroon to dark maroon-purple, with two broad green bands in line with the callus and subcallus respectively.

Seasonal Occurrence. These flies were very scarce indeed during the period February 1919 to September 1920. Females were seen or captured in the field in the months of January, February, April, June, September and December, generally while buzzing about one's head or resting upon one's hat. Horses (locally and in the Northern Territory) appear to be more troubled than cattle, the former usually being bitten about the nose, ears, rump and coronet.

Tabanus nigritarsis, Tayl.

T. nigritarsis, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 67.

Distribution. This species has been recorded previously from North Queensland (Houghton River) and the Northern Territory (Darwin, Stapleton, etc.).

Breeding-places and Habits. Between the 19th May and 10th June 1919 five apparently full-grown larvae were gathered from the submerged stems or leaves of various plants growing in a few feet of water at the margin of a small swamp (Locality No. 3, Plate II) and removed to a concrete trough containing a pile of sand at one end and water at the other. In this vessel they were fed upon molluscs until 3rd July, after which date food was refused by them. The water was now drained off and the sand allowed to dry gradually until only the bottom two inches remained moist, in which condition it was kept for about four months. On 19th August one of the larvae was found in a vertical position about three inches below the surface of the sand. The body was then much contracted, but when placed on the surface the insect became more or less active and extended its length to about 25 mm. This specimen was allowed to bury itself again, and remained undisturbed in the sand until 8th October, when it and two other larvae were found in the above condition. One of these was preserved in the usual way and is described in these notes ; the others were placed separately in five-inch flower-pots full of sand and imbedded in the sand contained in the larger vessel, where the two remaining larvae of the original batch of five were presumed to be resting. The two larvae in pots remained very active, but refused to eat either molluscs or earthworms, although they came to the surface almost nightly until 18th November. On 26th November one of these larvae was found undergoing metamorphosis, the other following on the morning of 1st December (11 a.m.), the former producing a female fly on 12th December and the latter a male on 17th December (between 9 and 10 a.m.).

On 27th November the sand in the large trough was sifted and another larva secured, which pupated on 12th December (5 p.m.) and produced a female fly on 28th December. The fifth larva was not recovered and was, therefore, presumed to have been destroyed by its fellows during the early days of their captivity. From the foregoing it will be seen that the pupal period in the laboratory was 16–17 days. Throughout the greater part of their lives in captivity these larvae and pupae showed much restlessness, and in the latter days of their pupal existence frequently wriggled to the surface or projected the posterior end above it, proceedings which would have been impossible under natural conditions owing to the hardness of the soil in which they would have been embedded.

As previously noted (under *T. aprepes*) a few larvae of this species were found in the resting stage in a clayey bank in this locality on 25th April 1920, associated with *T. aprepes* and *T. rufinotatus*. On 15th June following five additional specimens of *T. nigritarsis* were taken under similar conditions in the same locality. At the time of writing (30th September 1920) the majority of these are still in the larval stage in moist sand, others which at the time of capture were embedded in balls or tubes of plastic clay and placed on the laboratory shelves to dry were equally healthy and active when released on 30th September.

The Larva. The adult larva measures about 35 mm. in length by 5·5 mm. in width and is cream-coloured, faintly blotched and banded with yellow ochre (figs. 14–17). The pseudopods are arranged two on either side of the median line on the ventral surface and one on each pleura, these and the dorsal tubercles being only slightly elevated. The surface of the cuticle is dull and distinctly marked with longitudinal striae, except where banded or blotched.

The Pupa. The pupa measures about 23 mm. in length by 4 mm. across the thorax and 5 mm. across the abdomen at the widest part. The eyes are blackish brown, the thorax slightly lighter and the abdomen argus-brown. The first abdominal segment bears two slender hairs on either side of the median line, one on each pleuron behind the spiracle, and two closely approximated hairs on the ventral surface near the margin of the wing-sheaths. On the dorsal surface of the 2nd segment there is a double row of bristles, the anterior row short, stout and of irregular size, the posterior much longer ; the 3rd segment is similar to the 2nd ; on the 4th, 5th and 6th the bristles increase in size gradually from the 4th posteriorly ; on the 7th there are fewer long bristles in the posterior row, their place being occupied by others of intermediate size.

On the pleurae the armature is similar to that of the dorsum, except on the 7th segment, which resembles the ventral surface. On the ventral surface the 1st, 2nd and 3rd segments bear a single row of mixed short and long bristles increasing in length from the 2nd; the 5th and 6th segments resemble the corresponding segments of the dorsum, the 7th is similar, but has some short bristles in the posterior row. The integument of both surfaces bears transverse striae on the anterior two-thirds of each segment, which are generally absent or replaced by punctures on the posterior third. The armature of the terminal segment is variable. In most specimens there

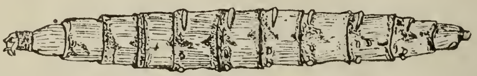

Fig. 14. *Tabanus nigritarsis*, Tayl., adult larva, lateral view.

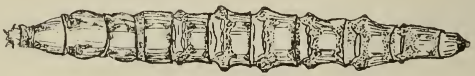

Fig. 15. *T. nigritarsis*, adult larva, dorsal view.

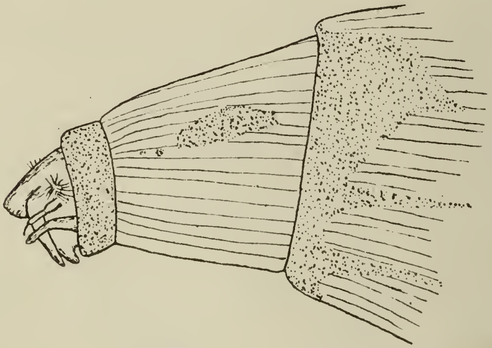

Fig. 16. *T. nigritarsis*, anterior end of adult larva.

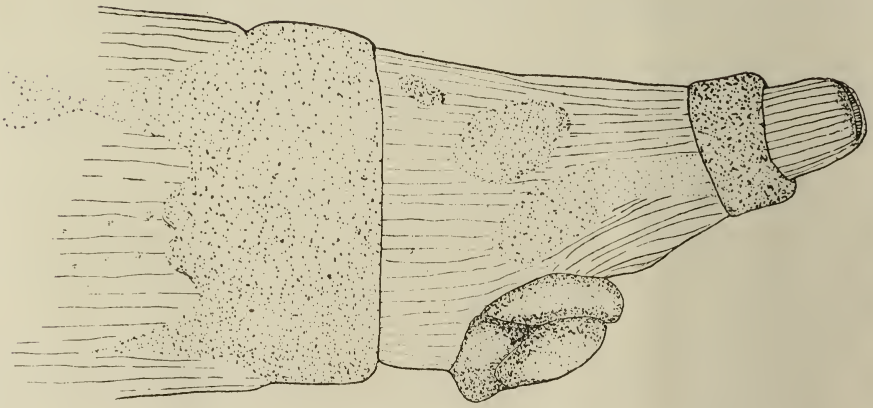

Fig. 17. *T. nigritarsis*, posterior end of adult larva.

is on the dorso-lateral margins, and midway between the base of the second pair of projecting spurs and the posterior margin of the 7th abdominal segment, a well-developed group of from five to seven very irregular bristles arising from a raised base. In some specimens these bristles are reduced to three or four in number, and in one they are absent on one side and on the other represented by two rudimentary bristles. In the male the anal opening is bordered anteriorly by a semicircle of stout and very irregular bristles, some of which are expanded and branched at the base, others short and almost rudimentary, or all may be long and moderately slender. Posteriorly the opening is bordered by a raised and deeply furrowed prominence. In the female (fig. 18) the fringe of bristles in front of the anal opening is broadly interrupted in the middle, each group being composed of from five to eight bristles of variable size.

The Adult. In life the eyes of the male are dull yellow-green and coarsely facetted above the point of junction of the eyes on the front; below this and on the sides and posterior margin the facets are smaller and bronze-coloured, with gold and green iridescence. In the females the eyes are uniformly dull yellow-green.

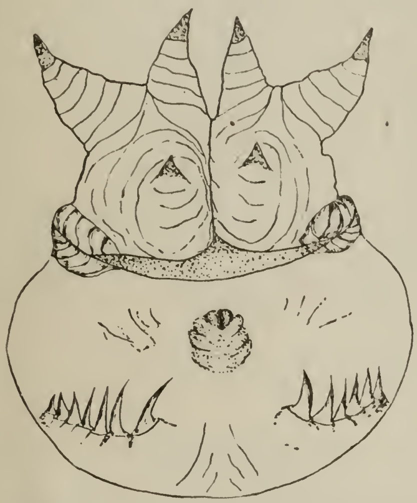

Fig. 18. *T. nigritarsis*, ventral surface of last segment of female pupa.

Seasonal Occurrence. Apart from the three flies reared in the laboratory only two individuals (females) have come under my notice during the period 25th February 1919 to 30th September 1920. Both were captured whilst attacking horses during the last week in February of this year. In the Northern Territory (1912–1917) this species was regarded as the most numerous and most troublesome to stock during the months of December-February. The egg-masses found there were small and compact and were generally placed on the underside of pandanus leaves overhanging water.

Silvius notatus, Ric.

S. notatus, Ricardo, Ann, Mag. Nat. Hist. (8) xvi, 1915, p. 264.

S. psarophanes, Taylor, Proc. Linn. Soc. N.S.W. xlii, 1917, p. 520.

S. fuliginosus, Taylor, *op. cit.* xl, 1915, p. 810.

Distribution. This Tabanid is a widely distributed species, having been recorded from S.W. Australia, Victoria, New South Wales, South Queensland, North Queensland and the Northern Territory (*S. fuliginosus*, Taylor).

Although so widely distributed, it would appear to be a rare species in this district, where, apart from those referred to above, only one specimen (the type of *S. psarophanes*) has been recorded hitherto. Nothing is known of its early stages and the feeding habits of the larvae and adults.

Breeding-places and Habits. On 22nd August 1919, while breaking down and sifting the low banks of a small lily-covered pool (Locality No. 3) about 24 Tabanid larvae were found in nearly dry, stiff, loamy soil at depths below the surface varying from 10 to 30 cm. In most cases the larvae lay in a vertical position with the head uppermost, others lay horizontally, and a few vertically with the head downward. At the time the bank was distant 12 feet from the water's edge and six feet from the mud which intervened between it and more or less dry soil. All the larvae were in the lower part of the bank in soil which had been above water-level since about 12th May, and although a search was made in the mud and adjacent dry soil no larvae were found there. The undamaged larvae, 16 in number, were removed to the laboratory and placed in two five-inch flower-pots containing moist soil, in which they remained undisturbed until 8th October. From the 22nd August until 22nd September they were very restless and wandered over the surface of the soil at night. These movements ceased on the latter date, and on the 8th October about one inch of the surface soil in one pot was temporarily removed, exposing the head and thorax of three pupae. The colour of the eyes and wing-sheaths indicated that they were then from about three to five days old. The oldest was preserved as a specimen, and the others were placed separately in pots of earth, from which they emerged as flies (♂ and ♀) on 13th October after a pupal period of about eight days. On the same date two males emerged from the second pot. Other flies emerged as follows:—1 ♂ on 25th October, 1 ♂ on 3rd November, 1 ♀ on 8th November, 1 ♂ on 24th November, 1 ♀ on 26th November, 1 ♀ 30th November, 1 ♂ 2nd December (pupal period 14 days), 1 ♀ 12th December.

On 15th June 1920 two resting larvae were taken from the bank shown in Plate II, fig. 2, and were transferred to small pots of sand, where they still remain in the larval stage (30th September).

The Larva. The adult larva measures about 33 mm. long by 4 mm. wide and is of a creamy white colour with narrow orange citrine bands at the anterior end of each of the first ten segments. On the first three segments the banding is obscure and on the 11th it is confined to a collar-like expansion of the posterior margin. Each abdominal segment, excepting the last, bears a slightly elevated transverse ridge or tubercle about half as wide as the segment, as well as a pseudopod on either lateral margin and a pair of pseudopods on the ventral surface. Macroscopically the dorsal and ventral surfaces are similar in appearance. The integument is glabrous and bears very distinct longitudinal striae. The first and last segments, and especially the spiracle (figs. 19, 20), differ greatly from those of any species of the genus *Tabanus* known to me. Grabner's organ has not been made out.

The Pupa. The pupa measures from 18–20 mm. in length, 3–3·5 mm. in width across the thorax, and 3·5–4·0 mm. across the widest part of the abdomen. The colour varies, according to age, from chestnut-brown to mars brown, head and apices of wing-sheaths blackish brown, lower surface and sides of first abdominal segment ochraceous tawny. In the male the head is as wide as the thorax, in the female slightly less. The abdomen is nearly cylindrical in both sexes. The thoracic spiracles are large and overlap the posterior margin of the head. The first abdominal segment bears two slender hairs on the tergite and one on each pleurite near the wing-sheath. The second tergite bears an interrupted single row of very short stout and irregular bristles and three or four long bristles, generally towards the sides. The third, fourth and fifth tergites are similar, except that the bristles are stouter and there are about eight long bristles on each. On the sixth and seventh tergites the bristles are fewer and stouter than on the preceding ones. On the pleura they are arranged roughly in two rows, those in front being much shorter and fewer than those behind. Sternites 2–7 are armed similarly to their corresponding pleurites. On the anterior half of each tergite there are five or six small dark-coloured depressions, the foremost being nearest the pleura and the hindmost nearest the median line. Behind the anterior margin of each segment and parallel with it there is another row of three or four similar depressions on either side of the median line. The anterior two-thirds of each tergite, pleurite and sternite are distinctly marked with transverse striae; posterior to the bristles these striae are less distinct or absent and the whole surface is punctate.

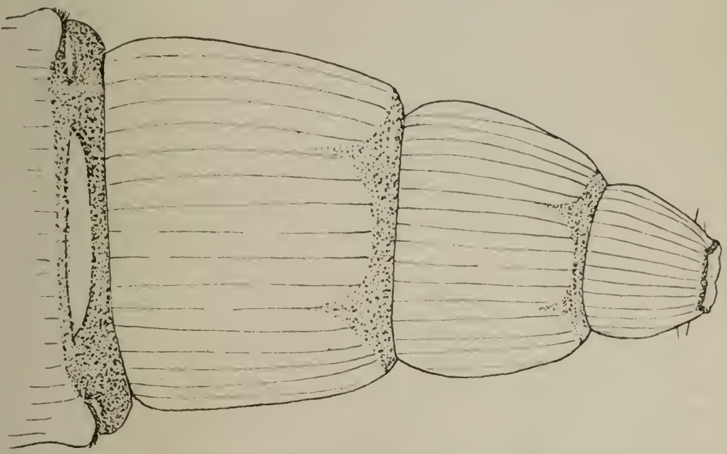

Fig. 19. *Silvius notatus*, Ric., anterior end of adult larva.

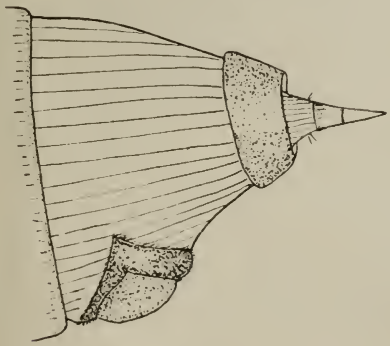

Fig. 20. *Silvius notatus*, posterior end of adult larva.

The terminal segment is deeply rugose, the two upper projecting spurs or bristles are parallel along their inner margins in the female and divergent in the male; the middle pair is much larger than the upper and lower and projects laterally. The anal tubercle of the male is very large and deeply furrowed; in front it is bounded by a continuous fringe of bristles, four or five comparatively small ones in the middle and a group of four or five very stout ones on each side, similar to but larger than those of the female (fig. 21) ; the latter group of bristles is continued, with a slight interruption, around the sides of the segment to a point in line with the base of the lower pair of spurs. The size and number of these bristles are variable in both sexes, but are generally largest and fewest in the males.

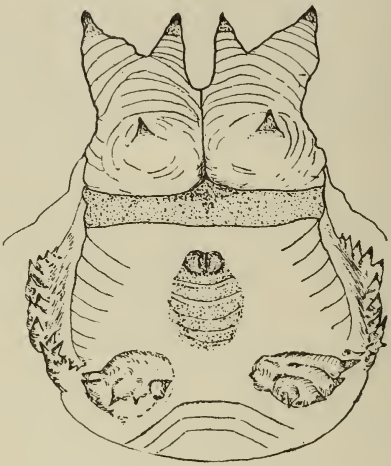

Fig. 21. *Silvius notatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the female are of uniform light seal-brown and the facets of equal size throughout. In the male the greater part of the surface of the eye is of the same colour, but at the lower third it is crossed by a sinuous, iridescent blue-green and copper band, which extends to near the lateral margins and is continued (in light seal-brown) around the posterior margin to the vertex. The facets forming this band are very small, while the remainder are large.

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XIV. THE EXTRACTION OF MELANIN FROM SKIN WITH DILUTE ALKALI.

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(Received December 23rd, 1920.)

It has generally been assumed that the black pigments (melanins) which occur normally or pathologically in animal tissues, hair, skin, feathers, etc. are chemically very inert substances, and in most cases their isolation has been carried out by dissolving the tissue in boiling alkalies or strong acids. Thus Abel and Davis [1896] prepared melanins from both the skin and hair of a negro by heating the material at 100° either with 5–6 % potassium hydroxide or with concentrated hydrochloric acid until all the keratin had dissolved. Other investigators have used even more drastic methods such as boiling with more concentrated alkalies or even fuming hydrochloric acid.

That some melanins are really not so resistant to alkalies and acids was shown by Gortner [1910] who investigated the effects of alkalies upon the melanin of black-sheep's wool. He extracted the pigment from the wool by boiling with successive portions of a 0·2 % solution of sodium hydroxide, and from the first two or three extracts he obtained a melanin of constant composition, $C = 52{\cdot}57\ \%$, $H = 7{\cdot}28\ \%$, $N = 13{\cdot}43\ \%$, $S = 1{\cdot}33\ \%$. This substance when purified contained no ash, was soluble in alkali and in very dilute mineral acids ($N/20$), and was precipitated by stronger acids. After boiling this with stronger alkali a pigment could be precipitated by acid from the solution, which contained less nitrogen and hydrogen than the original, and was no longer soluble in dilute acids.

This acid-soluble pigment was only obtained from the first two or three extractions, the subsequent extracts yielding a different pigment, insoluble in acid and containing less nitrogen and hydrogen, and Gortner considered this to be a decomposition product of the acid-soluble pigment.

When stronger solutions of alkali were employed for the extraction, the compounds obtained were insoluble in acid, and their nitrogen and hydrogen decreased, in general, as the concentration of alkali increased; thus the substance extracted with 50 % sodium hydroxide contained only 3·84 % hydrogen and 8·98 % nitrogen.

So far from being inert to alkalies the melanin of sheep's wool was thus readily decomposed by boiling with sodium hydroxide in concentrations over 0·2 %, whilst even this concentration decomposed the pigment on continued boiling.

From these results Gortner considered that in all probability many of the melanins described in the literature were really products of the decomposition of melanin and not the pigment as it occurs in the natural material.

The melanin obtained by Abel and Davis from negro skin was left in the form of pigment "granules" (pigment and pigment structure) after the keratin had dissolved in the alkali; and the pigment was freed from the pigment structure by continued treatment with 5 % hydrochloric acid, and subsequent extraction with potassium hydroxide. It then had the composition C = 53·56 %, H = 5·11 %, N = 15·47 %, S = 2·53 %.

The author [Young, 1916] described the preparation of a melanin from the skin of an Australian aboriginal, by treatment with successive portions of boiling 5 % sodium hydroxide, each portion being allowed to act for a short time only. In this preparation no granules were obtained but the pigment was gradually dissolved in the alkali, from which it was obtained by precipitating with acid. The analysis differed from that of the preparation of Abel and Davis as it gave C = 60·12 %, H = 6·70 %, N = 11·89 %.

More recently an opportunity of obtaining more material came to hand, and further preparations were made, the method being modified so that a more dilute alkali (*N*/20) could be employed in the extraction. Pigments were extracted with this alkali from portions of the skin from two Australian aboriginals and a low caste Cingalee.

Preparation.

It was found that if the skin were soaked in boiling water, the outer layer, which contained practically all the pigment, could be readily removed by scraping. This layer (200 g.) was washed with alcohol and ether to remove grease, and was boiled with 100 cc. of *N*/20 sodium hydroxide for one hour under a reflux condenser. It was allowed to settle and the dark liquid decanted and filtered. The process was repeated with successive portions of fresh alkali until, after four extractions, there was only a very small residue. To the four clear filtrates after cooling, hydrochloric acid was added to about *N*/3, whereby the melanin was thrown down as a dark-brown precipitate. It was allowed to settle, the liquid siphoned off and the precipitate repeatedly washed by decantation with *N*/3 hydrochloric acid. The clear washings were siphoned off as much as possible and water and hydrochloric acid added to make the liquid to 500 cc. of *N*/20 hydrochloric acid. The mixture was then heated to boiling. The precipitates from the first two extracts completely dissolved to a deep brown solution; that from the third extract was only partially soluble; whilst the fourth precipitate did not appear to dissolve at all. The solutions were filtered through a fine filter paper (Schleicher and

Schüll's Blue Band), and the first three solutions mixed. In this way the pigment was separated into two fractions, one soluble, the other insoluble in dilute hydrochloric acid. The solution in hydrochloric acid was cooled, and concentrated acid added until the mixture was $N/3$. The melanin was thereby precipitated and was allowed to settle, the liquid siphoned off, and the residue washed several times by decantation with hydrochloric acid of the same strength. The process of dissolving in $N/20$ acid, filtering and reprecipitating was repeated once, the pigment was then again dissolved in the dilute hydrochloric acid, and the solution dialysed until the liquid no longer gave a precipitate with silver nitrate.

This treatment precipitated the pigment, which was then filtered off on a hardened paper, washed with distilled water, then with alcohol, finally with ether and dried. The paper was folded and extracted in a Soxhlet apparatus, successively with carbon disulphide, light petroleum and ether, and was dried at 100°. It was thus obtained as a black powder, and will be referred to as acid-soluble melanin. Before being dried the powder was readily soluble in dilute ($N/20$) sodium hydroxide, and in glacial acetic and concentrated sulphuric acids. It dissolved on warming in dilute ($N/20$) hydrochloric and acetic acids. After drying at 100° it dissolved only with difficulty in boiling dilute alkali, more readily in stronger alkali, and was almost insoluble in dilute hydrochloric acid.

The pigment from the later extractions of the skin, which was insoluble in dilute acid, was also purified by treatment on the filter paper repeatedly with boiling $N/20$ hydrochloric acid. It was then washed repeatedly with water and subsequently dissolved in warm $N/20$ sodium hydroxide. The melanin was precipitated by adding hydrochloric acid in slight excess, washed by decantation until free from acid, filtered and washed with alcohol and ether, and extracted as before with carbon disulphide, light petroleum and ether, and dried at 100°. This powder, after drying, dissolved completely, but only very slowly, in boiling alkalies.

In the above manner both acid-soluble and acid-insoluble preparations were obtained from the three skins.

Analysis of products.

The carbon and hydrogen were determined by burning in a current of oxygen by Dennstedt's method, lead peroxide being employed to keep back any oxides of nitrogen and sulphur. The yields of material were too small for a separate estimation of sulphur, and in some cases the sulphur was therefore estimated at the same time by Dennstedt's method. The quantity of barium sulphate actually weighed was very small, so that the results must only be regarded as approximate. Nitrogen was estimated by Kjeldahl, the heating with sulphuric acid being continued for four hours after the solution had become clear, as recommended by Dakin and Dudley with pyrrole compounds.

In one preparation nitrogen was estimated both by Kjeldahl's and by Dumas' methods with practically identical results.

In all cases before analysis the material was dried to constancy *in vacuo* at 100° over phosphorus pentoxide.

In some preparations which contained a high percentage of ash samples were again treated by suspending in *N*/3 hydrochloric acid in a dialyser, allowing the acid to dialyse away, and washing and drying as before, whereby the ash was very considerably reduced. In such cases the analysis before and after this treatment is given. The percentages are all calculated for the ash-free substances and the results are tabulated below.

	Sol. in dil. acid					Insol. in dil. acid				
	C	H	N	S	Ash	C	H	N	S	Ash
I. Aust. Black I:										
(*a*) ...	56·41	7·33	—	—	7·02	56·03	5·86	—	—	3·51
(*b*) After further treatment to remove inorg. matter	56·33	7·37	12·46	—	2·78	55·92	6·25	—	1·77	2·60
II. Aust. Black II:										
(*a*) Extracted by first portion of alkali	55·49	8·30	13·54	—	0·67	59·87	7·27	10·80	1·66	1·39
(*b*) Extracted subsequently	56·81	6·68	11·95 12·24	2·49	4·03					
III. Cingalee:										
(*a*) ...	56·01	6·24	—	—	5·47	56·06	6·58	13·27	2·37	3·09
(*b*) After further treatment	56·06	6·71	14·57	2·56	2·68					
Previously found with 5 % alkali	—	—	—	—	—	60·10	6·70	11·89	—	—

In all cases the ash was left as a light brownish powder, only partially soluble in hot hydrochloric acid, and containing a small amount of silica. Estimations of the iron in the ash were made colorimetrically with potassium thiocyanate, and the quantity was found to vary from nothing in one sample, to 7 % of the total ash in another, the latter quantity corresponding to 0·2 % of the original pigment.

The iron was therefore not an essential part of the melanin molecule.

The ash also contained a trace of sulphate.

From the foregoing analyses it is seen that the ash was materially reduced by treatment of the melanin with acid, without altering the carbon and hydrogen percentage calculated on the ash-free substance. It would appear, therefore, that the ash is not an essential part of the melanin.

Action of alkali on the acid-soluble melanin.

A small quantity (about 0·5 g.) of the acid-soluble pigment from the Cingalee skin was boiled with *N*/20 alkali in a reflux apparatus. The sample which had been previously dried at 100° dissolved only slowly, passing, however, completely into solution after about five hours' boiling. The boiling was continued for 15 hours, after which the mixture was cooled, exactly neutralised with N hydrochloric acid, and sufficient acid added to bring the whole to $N/20$. The melanin was partially precipitated, and even when heated to boiling some of the precipitate did not redissolve.

That this was not due to the drying alone was shown by warming another portion of the original dried melanin with the alkali until solution had taken place, neutralising and making to $N/10$ hydrochloric acid and boiling. In this case the melanin completely dissolved.

The pigment soluble in acid behaved, therefore, like Gortner's pigment, in that it was altered slowly by continued boiling with dilute alkali into a substance no longer soluble in dilute acid. Sufficient material was not available to test whether nitrogen and hydrogen were lost during this treatment.

DISCUSSION OF RESULTS.

It will be seen from the table of results that variations were found in the percentage composition of the different preparations. The acid-soluble pigment generally contained a lower carbon percentage and a greater percentage of nitrogen and hydrogen than the acid-insoluble pigment subsequently extracted from the same skin, although the insoluble preparations from one skin did not always contain less nitrogen and hydrogen than soluble preparations from another. It is observed also that in the case where the first extraction was kept separate the same difference was found between this and the pigment from subsequent extracts, although both pigments were soluble in acids. Continued boiling with dilute alkali converted the pigment soluble in acid to one insoluble in acid; it seems therefore probable that in extracting the pigment even with very dilute sodium hydroxide ($N/20$) it is gradually decomposed, losing nitrogen and hydrogen and gradually changing to a pigment insoluble in acid.

The melanin of black skin thus resembles that prepared from wool by Gortner in that a pigment may be extracted with alkali which is soluble in dilute acids, and which, on further heating with alkali, changes to a pigment insoluble in dilute acids, with loss of nitrogen and hydrogen. In this case, however, a constant product could not be obtained, and it is possible that none of the preparations represents the pigment as it occurs in the skin.

The preparations gave quite different analyses from the pigment from negro skin prepared by Abel and Davis.

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Reprint from *The Medical Journal of Australia*, September 3, 1921.

A COMPARATIVE STATISTICAL INQUIRY INTO THE PREVALENCE OF DISEASES, DEATH RATES, INFANTILE MORTALITY AND BIRTH RATES IN QUEENSLAND.

By **A. Breinl.**

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It is a generally admitted fact that climate and surroundings influence health and disease of a community to a great extent and this influence finds its expression in the vital statistics of this community. It is difficult to estimate disease incidence; the occurrence of notifiable diseases may be gauged by the numbers of notifications, but for all other diseases the number of admissions to the hospitals is the only approximate guide. The virulence of the diseases may be judged by the case mortality in the hospitals, that is, the percentage of deaths from the various diseases compared with the number of admissions. The general death rate, considered in connexion with the average case mortality and hospital admissions indicates the degree to which hospital accommodation is made use of by the population. In addition, infantile mortality rates and birth rates allow of far-reaching conclusions to be drawn as to the general health conditions and prosperity.

Up to the present figures in these respects were only available for the whole of Queensland, and for the individual hospitals, but no systematic inquiry had been undertaken as yet with the purpose of comparing health conditions of larger districts of Queensland.

The inquiry was made possible by the valuable assistance rendered by the Queensland Government Statistician, the Government Statistician of Victoria and Tasmania and by the Commonwealth Statistician, who have courteously made available the publication containing the basal data. It is quite clear that any statistical inquiry offers a great many sources of error, the errors varying in direct proportion with the magnitude of the figures. In Queensland the population becomes scantier and more scattered with the progress north and in a scantily populated area small numbers greatly influence the percentages. Table I. contains the population figures for the districts and Table II. the numbers for the yearly average hospital admissions for ten years (1902 to 1911) for the six districts which were utilized in the inquiry.

Table I.—Population of Districts of Queensland According to Census, 1881, 1891, 1901 and 1911.

	1881.	1891.	1901.	1911.	1918. (Estimated population.)
Coastal I.	80,932	161,394	189,974	234.038	263,311
Coastal II.	44,260	79,201	105,358	124,636	136,198
Coastal III.	22,726	60,502	83,542	93,993	98,786
Inland I.	40,979	56,017	75,377	110,372	137,838
Inland II.	12,440	18,819	24,038	26,607	27,588
Inland III.	2,288	10,397	12,175	14,733	16,367
Census District VII. and Shipping	9,900	7,388	10,968	9,973	8,459
Total	213,525	393,718	501,432	614,352	688,547

Table II.—Average Number of Hospital Admissions for 1902 to 1911.

Coastal Districts.		Inland Districts.	
I.	6,647	I.	2,775
II.	3,426	II.	1,620
III.	5,169	III.	887

The clinical diagnoses of the hospital cases are not always correct and the stated causes of deaths in the death certificates, especially in districts where the aid of a medical practitioner is not always obtainable, are sometimes of doubtful value in a statistical inquiry. It is, however, possible to minimize these sources of error by considering the figures for larger districts only and by extending the inquiry over a number of years; but the latter procedure introduces a new source of error, since the census in Australia takes place only every ten years. For a few years, following the census year, the estimated numbers of population are fairly correct, but the further the year is removed from the last census, the less reliance can be placed on the estimated population figures. In order to overcome this disadvantage the decade between two census years 1902 to 1911 was selected as the unit of comparison and only for completeness sake the average rates for the years after the census were calculated.

In addition, the well-recognized migratory character of the population of Queensland must exert a great influence upon the vital statistics, but it is impossible with the figures available to estimate its influence.

From a climatic point of view Queensland is far from uniform. There are distinct climatic changes, corresponding to the latitude, the averages of the dry and wet bulb temperature becoming higher with decreasing latitude; the coastal climate differs greatly from the inland climate, possessing lower average minima, higher average maxima and considerably lower average wet bulb readings. In addition the elevation above sea level and the total amount and monthly distribution of rainfall exerts a potent influence.

For the purpose of the statistical inquiry the whole of Queensland was divided into six separate districts, three coastal and three inland, the two southern districts situated roughly between 29° and 27° south latitude, the two central districts between 27° and 22° and the two northern districts between 22° and 17½°. Each of the districts comprises a number of census districts, for which separate vital statistical figures are available (compare map). The northern district (7th census district), situated between Port Douglas and Cape York, which includes the hospitals situated in Port Douglas, Cooktown and Thursday Island has not been considered in the present inquiry, since the returns of patients admitted to the Thursday Island Hospital include a large number of coloured persons and it was impossible to obtain the necessary data for the white population only; thus a consideration of the total hospital admission in relation to the number of white inhabitants would have given rise to erroneous conclusions.

Methods.

For the hospital statistics the returns of the various hospitals, published in the vital statistics of the State of Queensland were utilized. The first coastal district comprises the following hospitals:

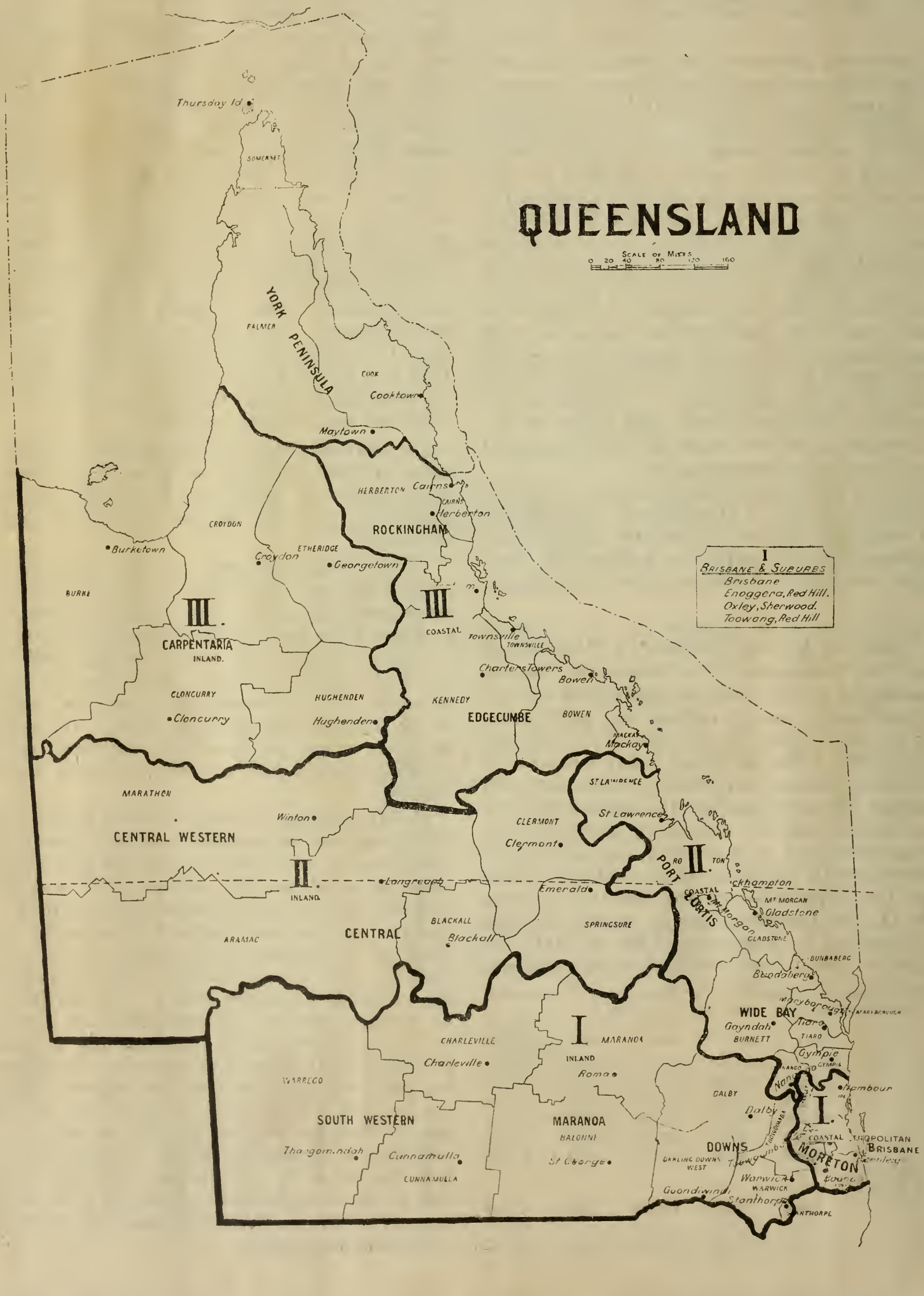
Brisbane General Hospital, Children's, Diamantina, Lady Lamington, Mater Misericordiæ, Beaudesert, Boonah, Ipswich, Laidley and Kilcoy.

The second coastal district:

Bundaberg, Eidsvold, Childers, Gayndah, Gin Gin, Gympie, Kingaroy, Maryborough, Mount Perry, Nanango and Wondai, Gladstone, Many Peaks, Mount Morgan, Rockhampton General and Children's Hospital.

The third coastal district:

Bowen, Ayr, Charters Towers, Mackay, Prosper-



pine, Townsville, Cairns, Chillagoe, Forsayth, Atherton, Innisfail, Ingham, Herberton, Irvinebank, Mareeba, Mount Garnett, Mount Molloy, Mount Carbine, Stannary Hills and Wolfram Camp.

The first inland district:

Adavale, Augathella, Charleville, Cunnamulla, Thargomindah, Mitchell, Mungindi, St. George, Taroom and Roma, Dalby and Dalby Sanatorium, Goondiwindi, Miles, Stanthorpe, Surat, Texas, Toowoomba and Warwick.

The second inland district:

Boulia, Kynuna, Winton, Aramac, Barcaldine, Blackall, Clermont, Emerald, Jundah, Longreach, Isisford, Muttaburra, Springsure and Tambo.

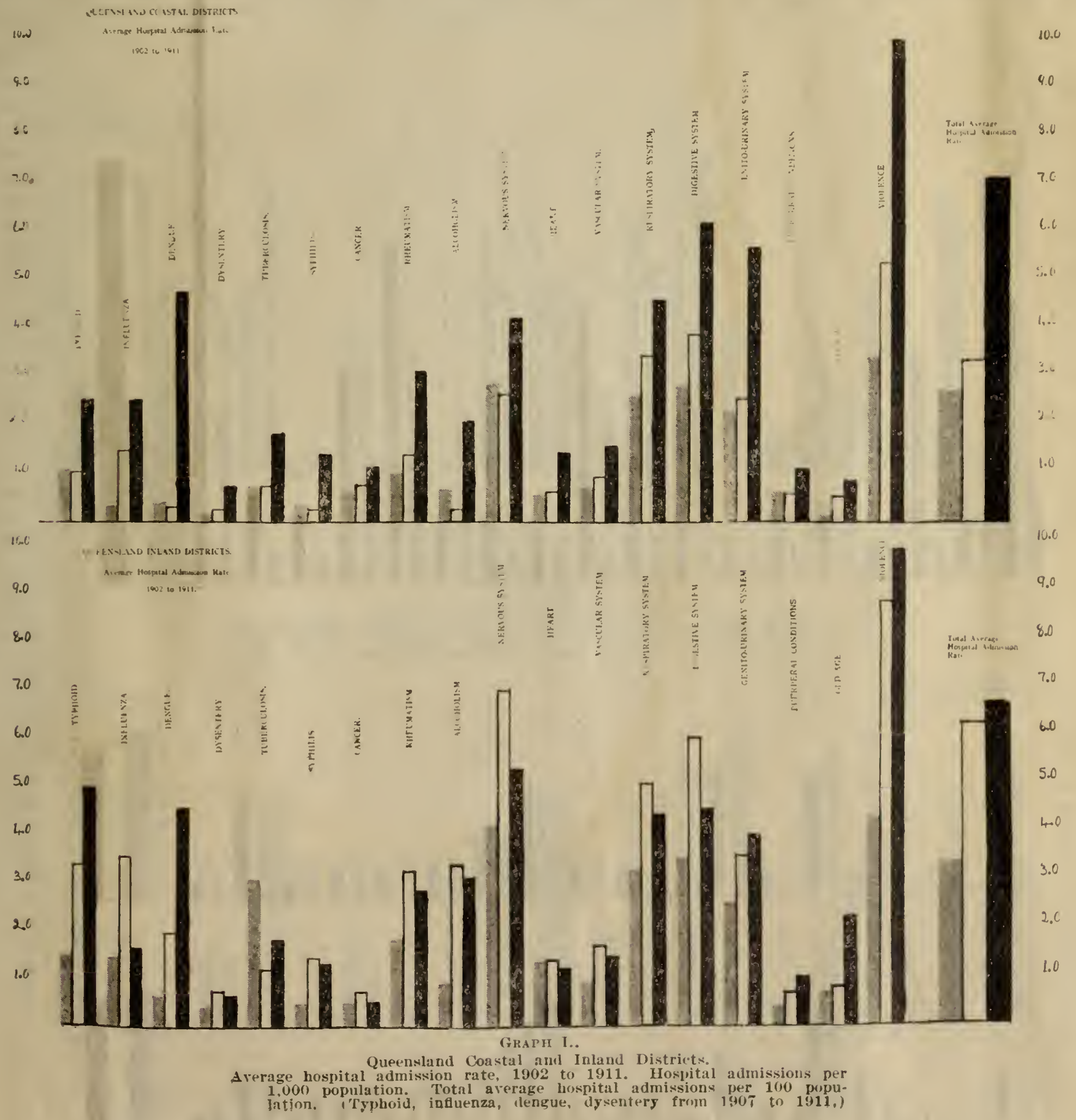
The third inland district:

Burketown, Camooweal, Cloncurry, Einasleigh, Croydon, Georgetown, Normanton, Hughenden, Kuridala, Richmond and Selwyn.

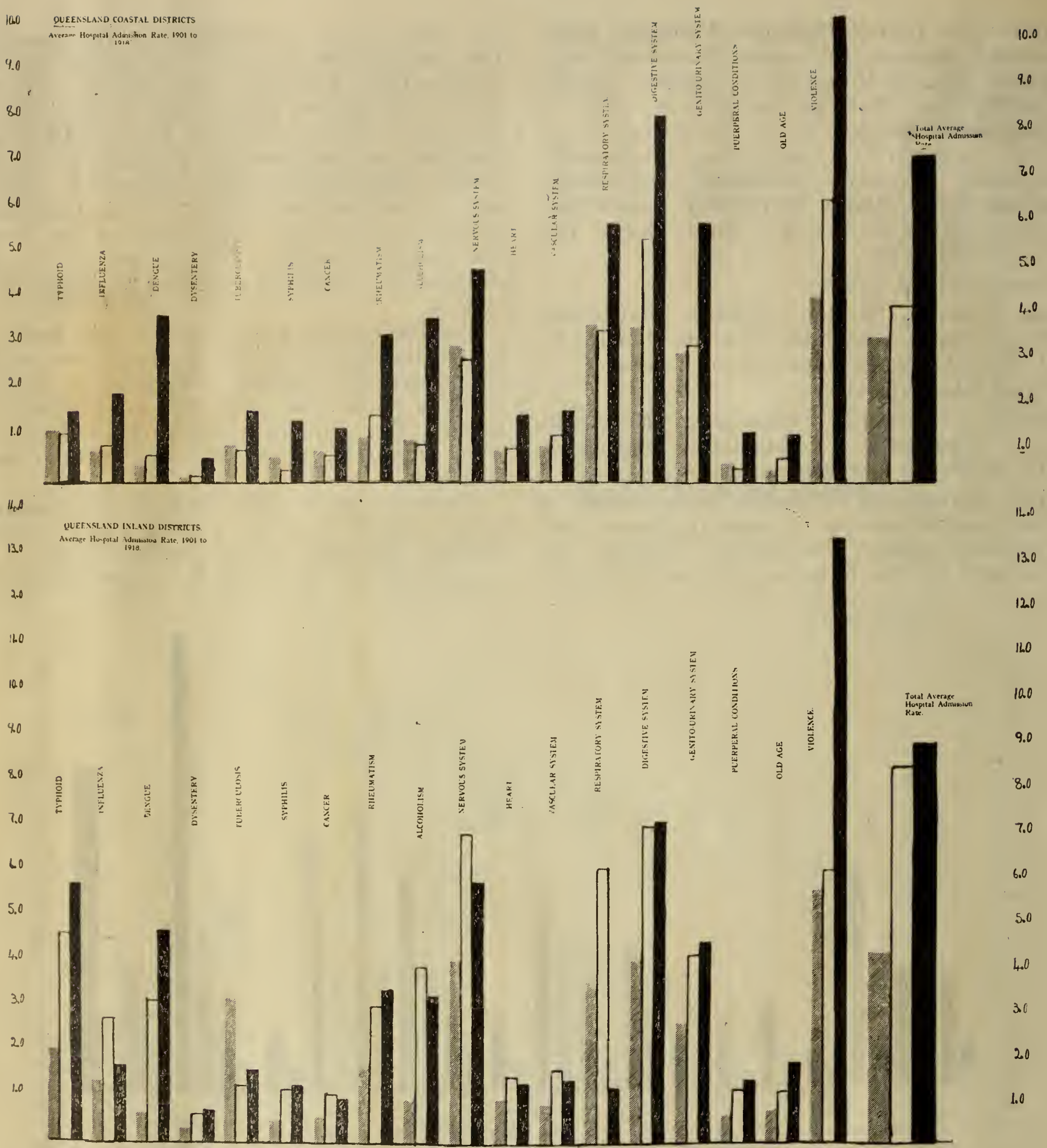
Separate figures were taken out for a number of individual diseases, namely, typhoid, influenza, dengue, dysentery, cancer, rheumatism, syphilis and alcoholism and for the following groups of diseases, *viz.*, the nervous, the respiratory, the digestive and the genito-urinary systems, including the diseases of the adnexa, puerperal conditions, old age, violence and in addition the average total from all causes was appended. The diseases of the circulatory system were divided into two sub-divisions, heart disease, which include pericarditis, endocarditis, organic diseases of the heart and *angina pectoris*, and diseases of the arteries in which were included the diseases of the lymphatic system. Throughout the inquiry the diseases were classified according to the full Bertillon system.

For the hospital admission rates the figures given in the vital statistics for north Queensland were taken out separately, arranged according to districts and the rate worked out in relation to the district population. The population figures from 1901 to 1918 were supplied by the Commonwealth Bureau of Statistics.

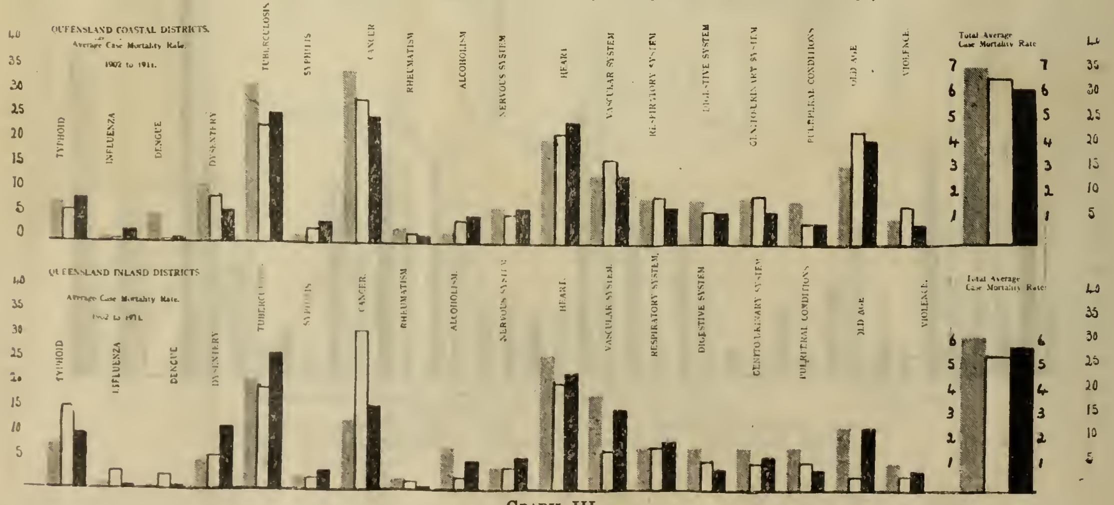
Separate graphs were made for the coastal and inland districts. In the graphs, under each disease heading, the first column represents the southern coastal district, the second the central and the third



GRAPH I.
Queensland Coastal and Inland Districts.
Average hospital admission rate, 1902 to 1911. Hospital admissions per 1,000 population. Total average hospital admissions per 100 population. (Typhoid, influenza, dengue, dysentery from 1907 to 1911.)



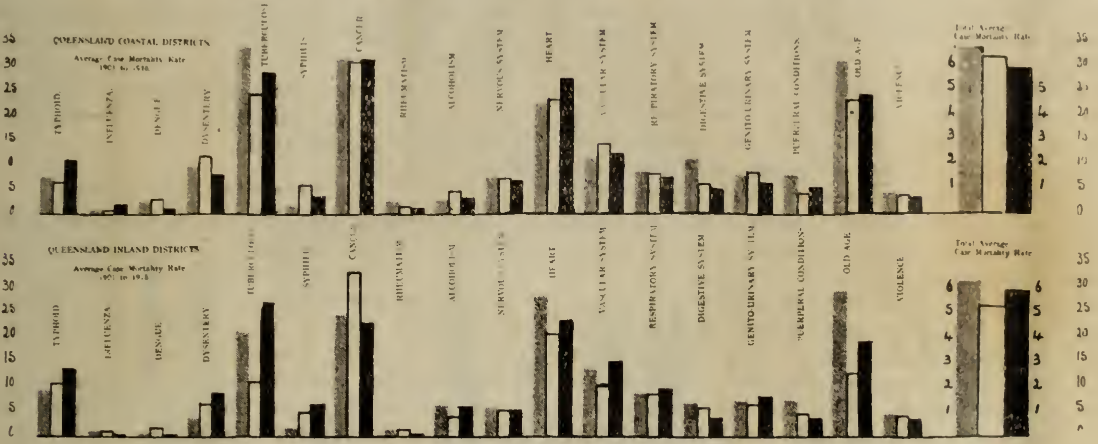
GRAPH II.
Queensland Coastal and Inland Districts.
Average hospital admission rate, 1901 to 1918. Hospital admissions per 1,000 population. Total average hospital admissions per 100 population. (Typhoid, influenza, dengue, dysentery from 1907 to 1918 only.)



GRAPH III.
Queensland Coastal and Inland Districts.
Average case mortality rates, 1902 to 1911 (Typhoid, influenza, dengue, dysentery from 1907 to 1911.)

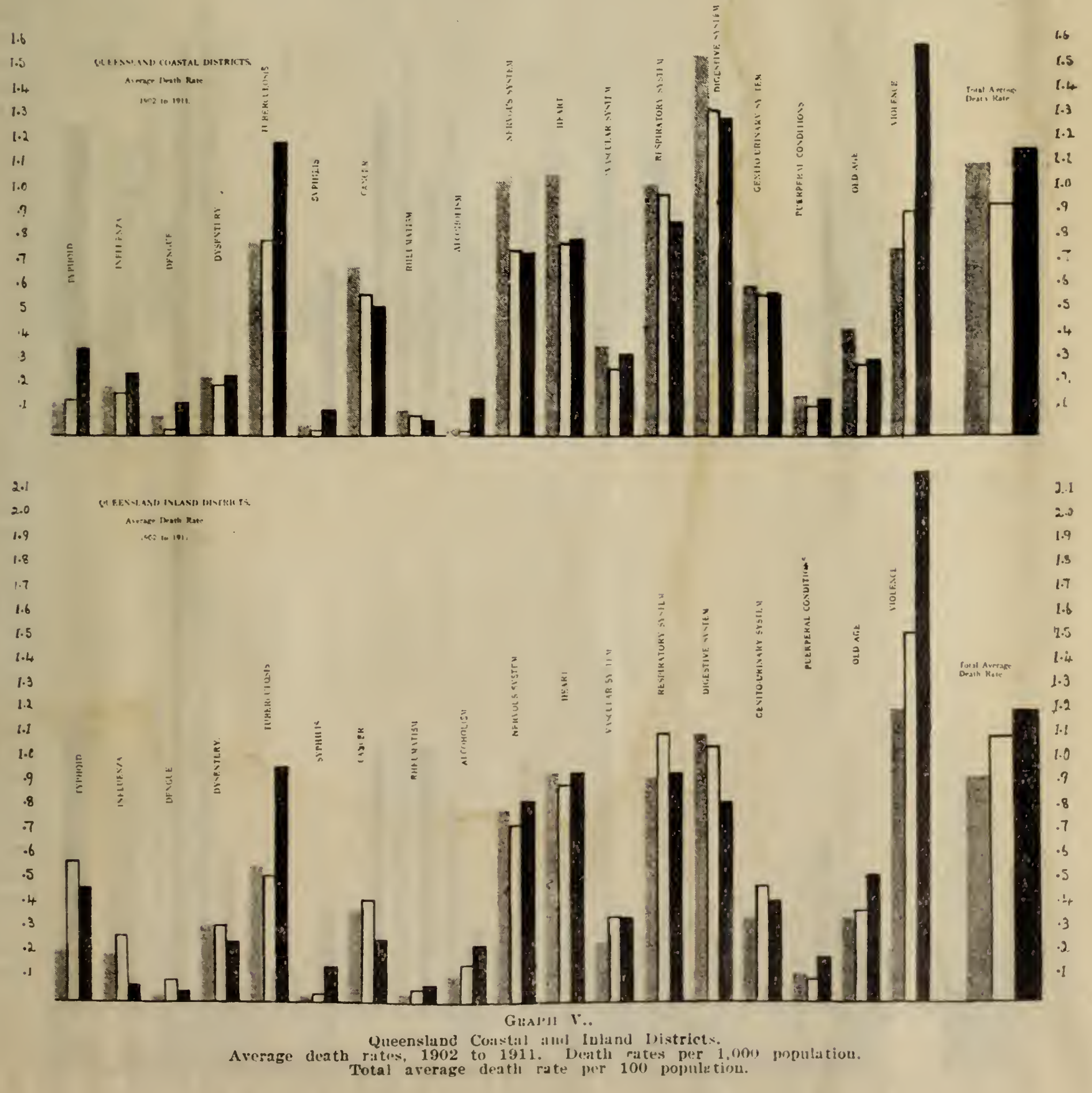
the northern coastal district; the same sequence has been employed for the inland districts. Graphs were made separately for the decade 1902 to 1911 and again for the years 1901 to 1918, representing the total number of years for which detailed hospital statistics are available. The graphs for the diseases represent the admission rate per 1,000 population, whereas the total average admission rate represents the total admission rate per hundred population.

The case mortality rate, *i.e.*, the percentage of



GRAPH IV.

Queensland Coastal and Inland Districts.
Average case mortality rates, 1901 to 1918. (Typhoid, influenza, dengue, and dysentery from 1907 to 1918.)



GRAPH V.

Queensland Coastal and Inland Districts.
Average death rates, 1902 to 1911. Death rates per 1,000 population.
Total average death rate per 100 population.

deaths in the hospitals in relation to the number of admissions for the same diseases for the same districts was calculated and graphically represented.

Similarly the district death rate was calculated per 1,000 of population and is presented in form of graphs. The column of the total average death rate represents the number of deaths per hundred inhabitants.

It was considered of interest to compare as far as possible the death rates according to districts during the times of the earlier settlement of Queensland. For this purpose the number of deaths was taken out according to the same diseases as previously. The census figures for 1881 to 1891 were obtained from the census reports. The increase and decrease in population respectively between the two census years was divided by ten and the factor thus obtained added to or subtracted from the population figure of the preceding year for each year. Thus population figures for the intervening periods were obtained representing a fair average. The average death rates for the three decades 1881 to 1890, 1891 to 1900 and 1901 to 1910 were utilized for the graph.

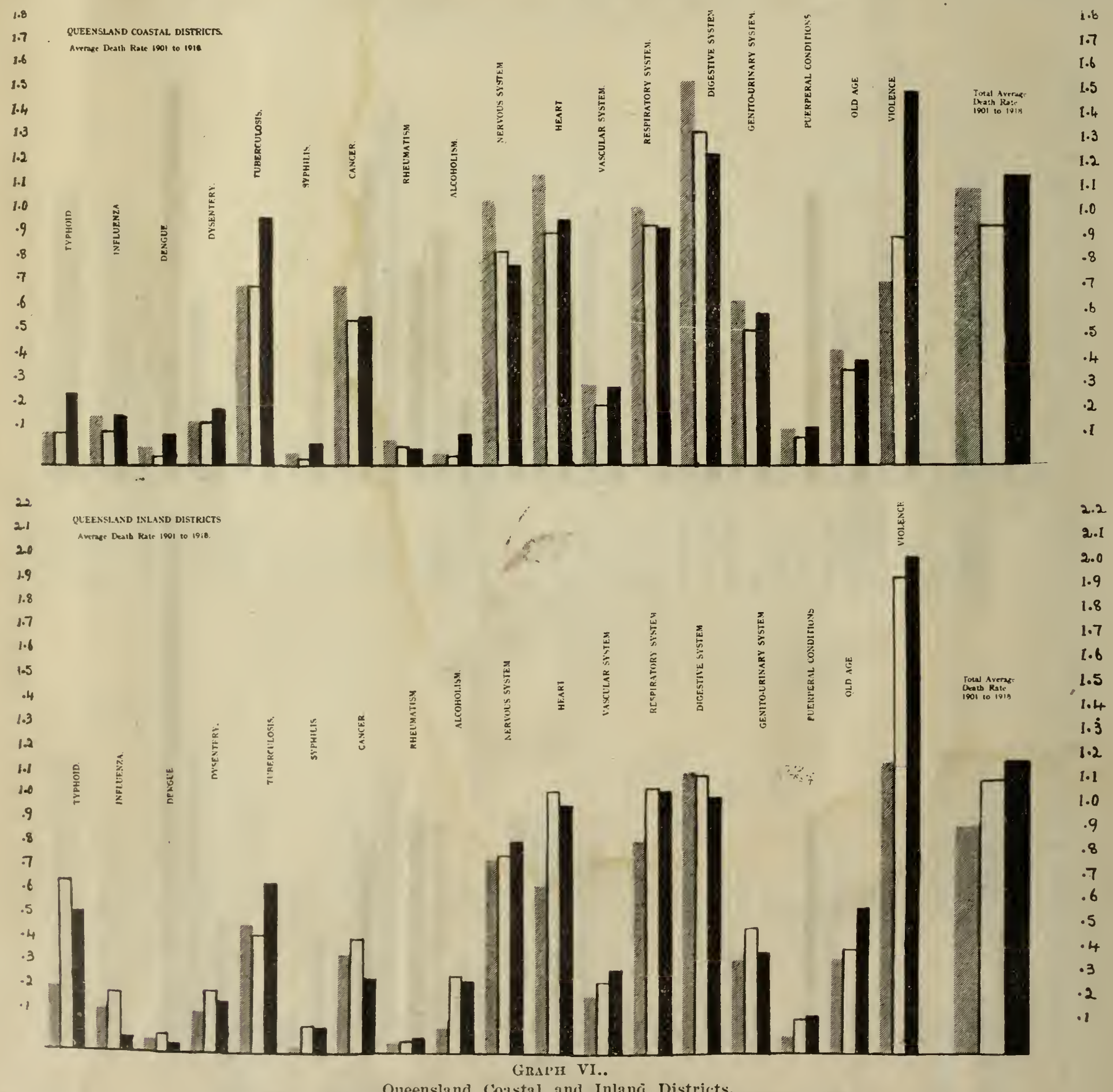
Great difficulties were encountered in working out the true infantile mortality in Queensland, that is, the relative number of deaths of children under one year of age per 1,000 births. Separate figures for the number of deaths under one year of age could only be obtained from 1907 onwards; prior to 1907 only the number of deaths of children under two years of age had been tabulated.

The birth rate was calculated in relation to the total number of inhabitants of each district and graphically represented.

I.—Hospital Admissions.

The average hospital admission rates from 1902 to 1911 are plotted in Graph I.. The admission rates for typhoid, influenza, dengue and dysentery represent the average for five years only (from 1907 to 1911) as no separate figures have been published in the vital statistics for the preceding years.

The graphs indicate that the hospital admission rates are much higher for the northern coastal districts than either for the central or for the southern districts. They show, however, on the whole, the same



GRAPH VI..
Queensland Coastal and Inland Districts.
Average death rates, 1901 to 1918. Death rates per 1,000 population.
Total average death rate per 100 population.

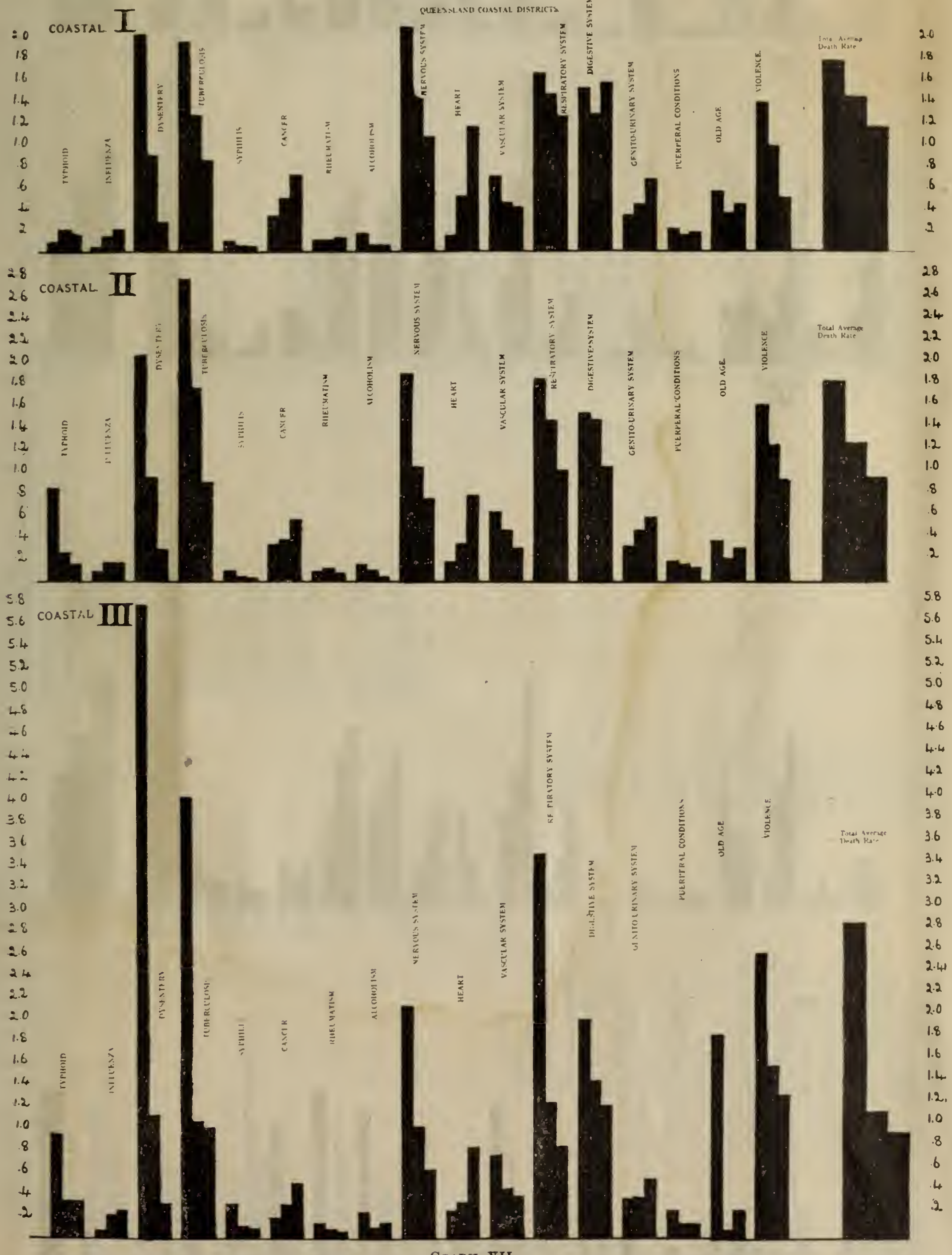
relative increase with the exception of admissions for dengue and violence, which are proportionately greater; the central district occupies an intermediate position.

For the three inland districts the relative proportions are different. Both the central and northern district show practically the same relative admission figures, which are much higher than the corresponding figures for the southern district.

The average hospital admission rates for 18 years (Graph II.), 1901 to 1918, for the same diseases and disease groups are very similar to those for the decade 1902 to 1911, the admission rate for violence in the third inland district being, however, much higher and showing an increase from 9.9 to 13.3 per 1,000.

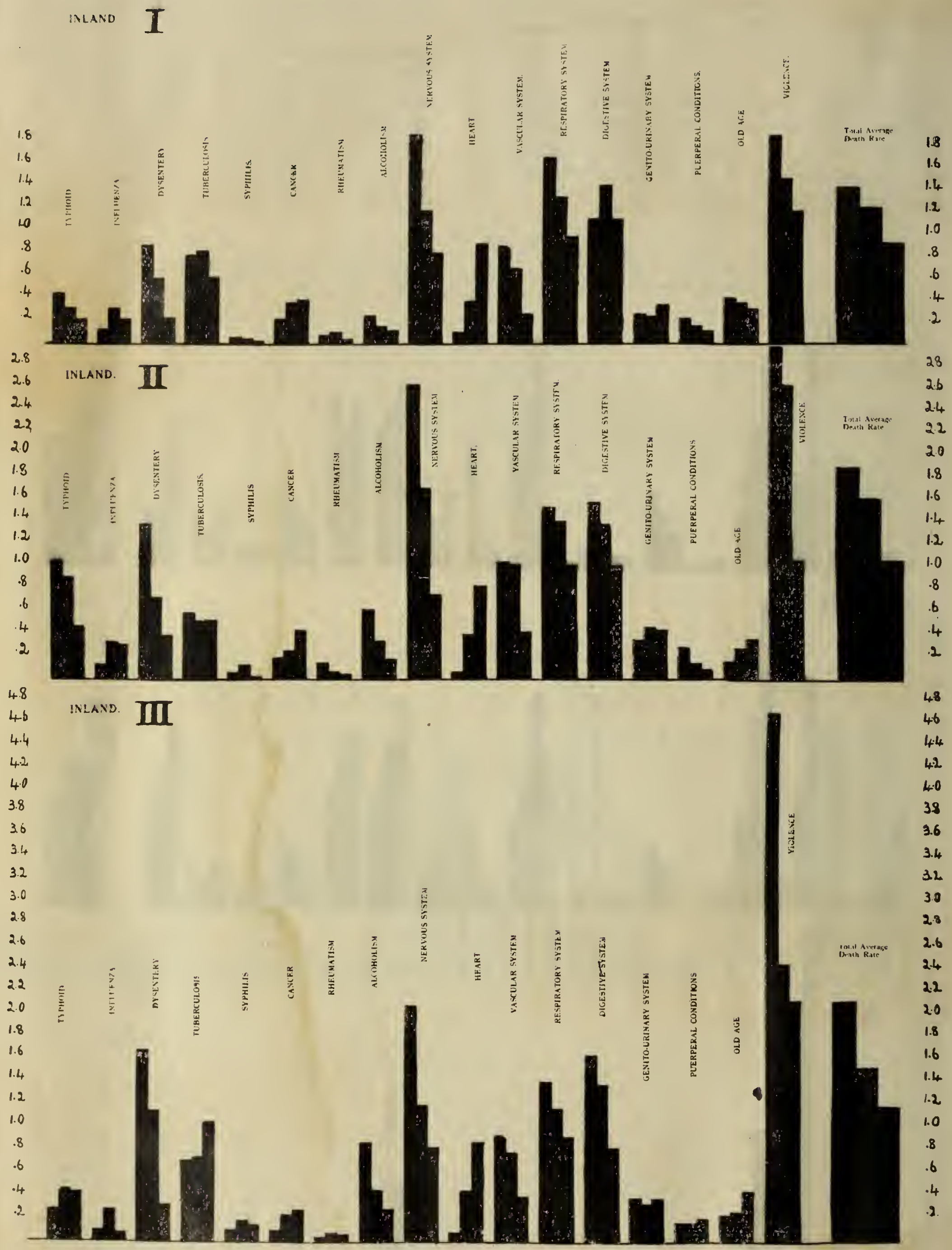
From a casual perusal of these graphs the impression may be gained that the northern parts are more unhealthy than the southern districts, but further

GRAPHS VII.-VIII.,
Queensland Coastal and Inland Districts.
Comparison of death rates by districts for the three decades from 1881 to 1910. Death rates per 1,000 population. Total average rate per 100 population.

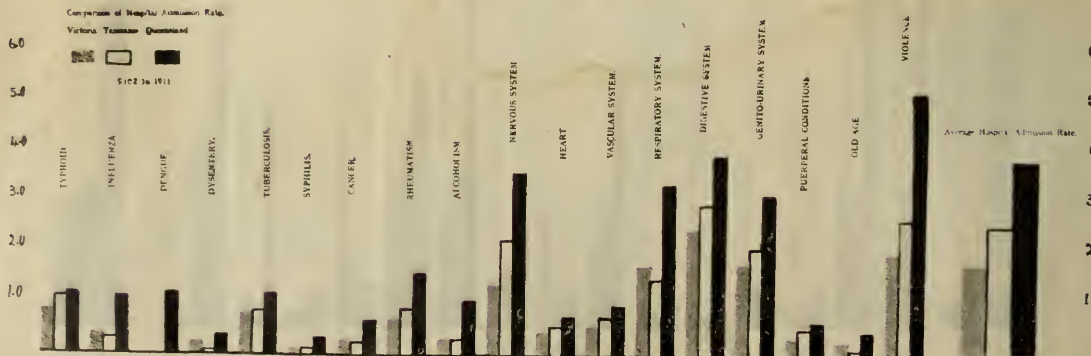


GRAPH VII.,
Coastal Districts.

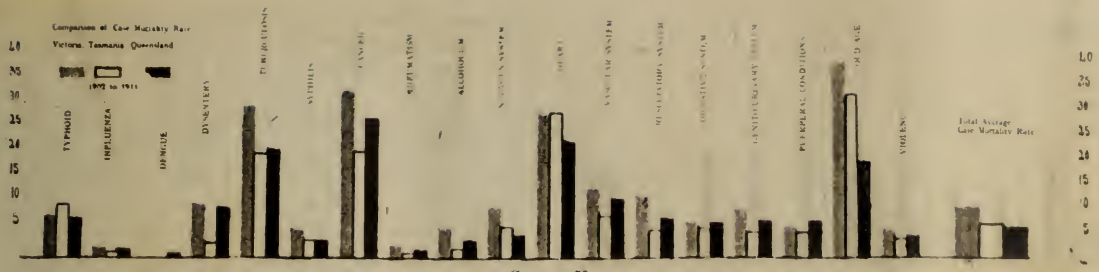
QUEENSLAND INLAND DISTRICTS.



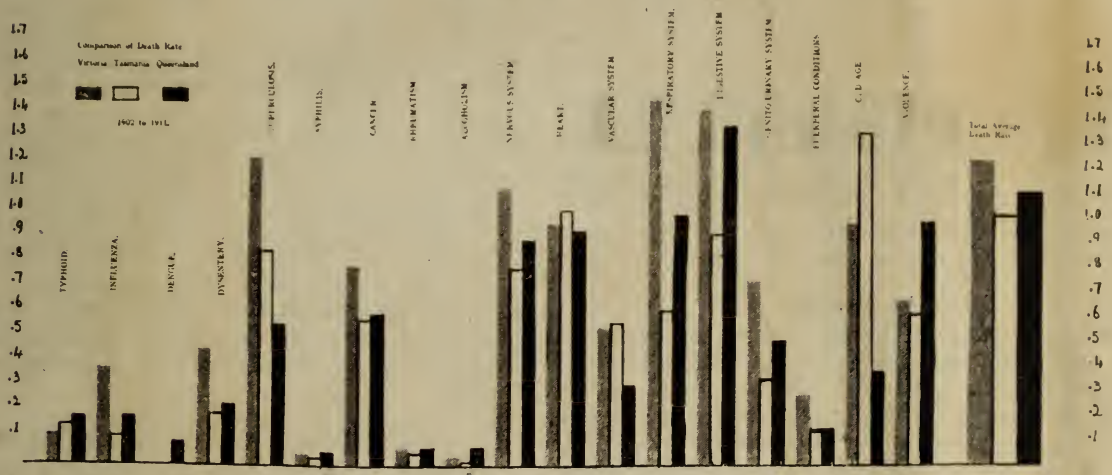
GRAPH VIII..
Inland Districts.



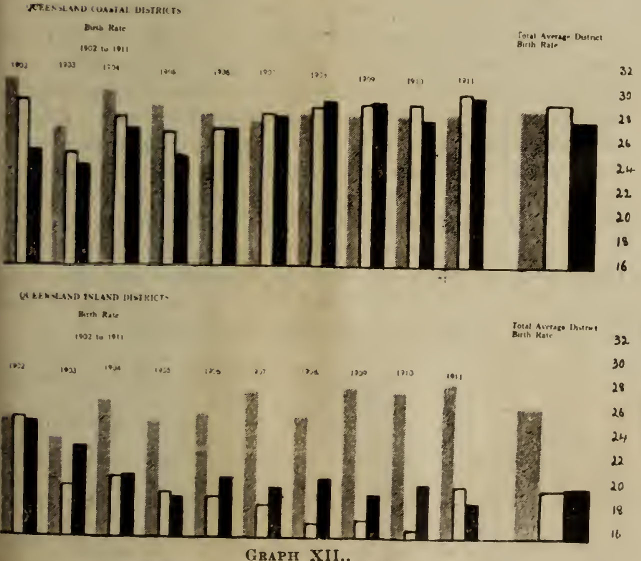
GRAPH IX..
Comparison of hospital admission rates Victoria, Tasmania, Queensland, 1902 to 1911. Hospital admissions per 1,000 population. Total average hospital admission per 100 population.



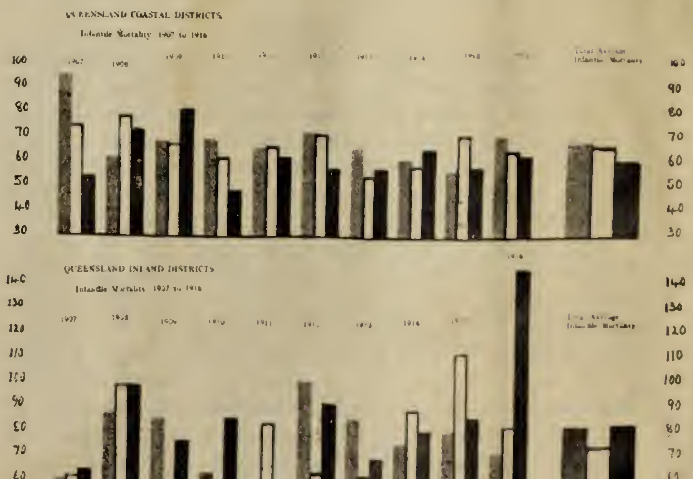
GRAPH X..
Comparison of case mortality rates (per 100), Victoria, Tasmania and Queensland, 1902 to 1911.



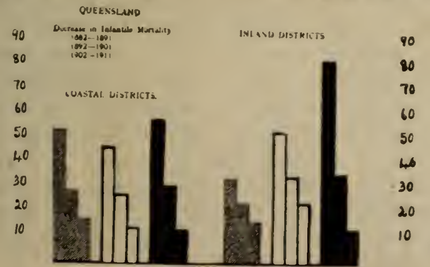
GRAPH XI..
Comparison of death rates Victoria, Tasmania and Queensland, 1902 to 1911. Average death rate per 1,000 inhabitants. Total average death rate per 100 population.



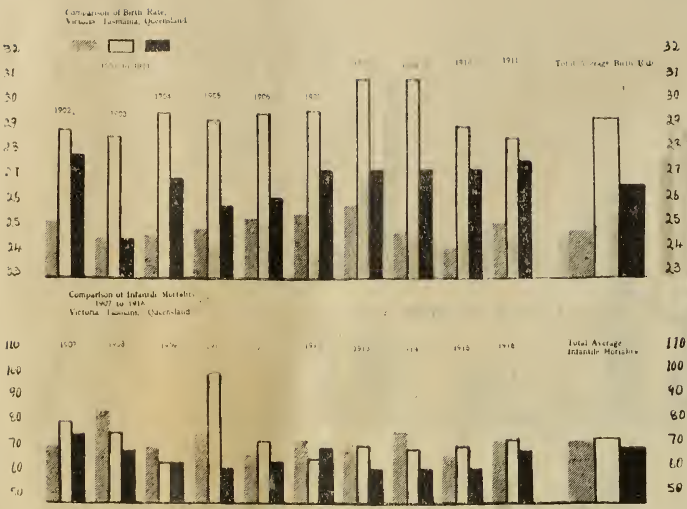
GRAPH XII..
Queensland Coastal and Inland Districts.
Comparison of birth rates per 1,000 inhabitants, 1902 to 1911.



GRAPH XIII..
Queensland Coastal and Inland Districts.
Comparison of infantile mortality, 1907 to 1916.



GRAPH XIV..
Queensland Coastal and Inland Districts.
howing the relative decrease in the number of deaths of children under two years of age for the three decades 1882 to 1911.



GRAPH XV..
Comparison of birth rate Victoria, Tasmania and Queensland from 1902 to 1911 and infantile mortality 1907 to 1916 for the same States.

consideration will prove clearly that the higher hospital admissions are due to other factors.

II.—Case Mortality.

In order to ascertain the severity of the cases admitted to the different hospitals, the case mortality, that is, the relative number of deaths in the hospitals per 100 admissions for the same disease or disease groups was ascertained for the years 1902 to 1911. The graph (Graph III.) shows that on the whole the case mortality does not vary to any appreciable extent according to districts. There are a few exceptions, *e.g.*, a relatively greater number of cases of cancer died in the second inland district. On the whole the conclusion seems justified that the cases admitted to the various hospitals are of about the same severity. The graph for 1902 to 1911 is practically identical with that for 1901 to 1918 (Graph IV.).

III.—Death Rates.

The district death rates per 1,000 inhabitants (total average per 100) for the same diseases (Graph V.) do not exhibit any great variations according to districts. Typhoid, tuberculosis, alcoholism and violence show a somewhat higher death rate in the northern coastal district and tuberculosis and violence in the northern inland district.

There can be but little doubt that the migratory nature of the northern population affects the death rate statistics to a greater extent than the hospital admissions; it would, however, be impossible to gauge the influence of this factor with the figures available at present. Graph VI., showing the death rates for 1901 to 1918, is practically identical with Graph V..

Consideration of the comparative figures for the hospital admissions in the different districts shows that hospital admissions for the northern districts are much higher than for the southern districts and the question arises as to the significance of this observation. The higher figures may either be an indication of a greater incidence of disease in general in the north or may find their explanation in a greater use of hospital facilities by the northern population. When regarding the hospital admission figures in connexion with the district death rates and case mortality rates a definite answer can be obtained. The figure for the average case mortality rates prove that o the whole the cases dealt with in the various hospitals are of a similar severity. Assuming now tha throughout Queensland the same relative proportio of the sick population were utilizing hospital facilities, the districts with a higher admission rate an a constant case mortality would necessarily show higher average district death rate. If, on the othe hand, the district death rates were the same or lowe the conclusion would be justified that the increase hospital admission rate is only due to the fact tha a greater proportion of the population avail themselves of hospital benefits. As in the northern districts of Queensland, both coastal and inland, th average death rates vary but slightly from those fo the other parts of Queensland (by one in thousan for the coastal and three in thousand for the inlan district), the conclusion seems to be justified that th increase in the hospital admissions does not indicat a greater incidence of disease in the northern part but only a greater use of hospital accommodation

Medical practitioners with experience in differen parts of Queensland bear out the truth of this statement; they assert that in many parts of north Queensland practically the whole of the population uses th hospitals.

Death Rates in Decades from 1881 to 1910.

In order to obtain as far as possible a medical history of the different districts of Queensland based o the death statistics, death rates for the same disease and disease groups as previously, for the same si districts for the three decades from 1881 to 1910 wer compiled and the results summarized in form of graph. The population was estimated in the way indicated above. Separate graphs for each distric (three coastal and three inland) were prepared. I each graph the first column under the disease heading represents the average death rate for the year between 1881 and 1890, the second column betwee 1891 and 1900 and the third from 1901 to 1910. I these graphs the rates for the diseases have been calculated per 1,000 and the total average death rat per 100 inhabitants (compare Table III.).

TABLE III.—TOTAL AVERAGE DEATH RATES FOR THE SIX DISTRICTS FROM 1881 TO 1910.

	Coastal.			Inland.		
Years.	I..	II..	III..	I..	II..	III..
1881 to 1890 ..	17.196	18.178	29.009	14.003	19.093	21.363
1891 to 1900 ..	11.991	12.490	13.652	12.179	16.130	15.660
1901 to 1910 ..	11.344	9.517	11.800	9.227	10.496	12.154

In general the graphs (Graphs VII. and VIII.) show a marked decrease in the total average death rate which decrease is most pronounced in the northern coastal district. It is of interest that in the six districts a similar tendency for certain diseases to increase or decrease can be noted. For example in every district the number of deaths due to diseases of the heart has increased, whilst the number of deaths due to vascular disease has decreased. Throughout Queensland the number of deaths due to cancer has steadily increased from decade to decade. Most striking is the decrease in the number of deaths due to dysentery and tuberculosis.

Comparison of Hospital Admissions, Case Mortalities and Death Rates of Victoria and Tasmania with Those of the Whole of Queensland.

As the previous graphs indicate in how far the vital statistics for the separate districts influence the figures for the whole of Queensland, it was considered of interest to compare the rates obtained for the whole of Queensland with the corresponding figures for Victoria and Tasmania. For this purpose hospital admission rates, case mortality and death rates were calculated for the whole of Victoria and for Tasmania for the same diseases and disease groups as previously for the years 1902 to 1911 and the results graphically presented.

The first column under each heading represents Victoria, the second Tasmania and the third Queensland.

A comparison of the hospital admissions (Graph IX.) proves that the hospital admissions are in every instance higher for Queensland than for the other two States. A comparison of the case mortality rates (Graph X.) for the three States proves that the case mortality rate is with few exceptions practically the same for the three States. The average death rate (Graph XI.) is highest for Victoria, lowest for Tasmania, whereas Queensland occupies an intermediate position on the whole.

A consideration of these graphs proves again that he relative larger number of hospital admissions does not signify a greater morbidity, but indicates that a arger relative proportion of inhabitants of Queensand make use of hospital facilities compared with Victoria and Tasmania.

Birth Rates.

A comparative statistical inquiry into the birth ates of the same districts, as utilized in the previous nquiry, was carried out. For reasons previously tated, the decade 1902 to 1911 was used as standard f comparison. The results were again tabulated or the three coastal and the three inland districts. The graphs (Graph XIII.) prove that the birth ate does not show any marked variation in the three oastal districts and that climatic conditions do not eem to influence the number of births.

For the inland districts the averages vary coniderably and are highest in the south. This differnce, however, cannot be attributed to climatic conitions alone, otherwise analogous changes would be oticed in the coastal districts, but may find its exanation in the fact that a much smaller number women of child-bearing ages live in the central and orthern inland districts. A calculation of the ratio the male and female population at the time of the 911 census proves this contention (Table IV.).

BLE IV.—RATIO OF MALE AND FEMALE POPULATION ACCORDING TO DISTRICTS, CENSUS, 1911.

Coastal Districts.	Males.		Females.	Inland Districts.	Males.		Females.
I. ..	1.007	:	1.000	I. ..	1.257	:	1.000
II. ..	1.154	:	1.000	II. ..	1.858	:	1.000
III. ..	1.370	:	1.000	III. ..	1.901	:	1.000

Infantile Mortality.

The Commonwealth Statistician pointed out that nother test of salubrity often applied is that deved from a comparison of the death of infants under one year of age with the total births.” Unfortunately for reasons stated previously, it was impossible to obtain data as to the number of deaths of infants under one year of age prior to 1907 and the decade from 1907 to 1916 has been selected as standard of comparison. Graph XIII. represents a comparison of the true infantile mortality (number of deaths of infants under one year of age in relation to 1,000 births) for the three coastal and three inland districts. In the coastal districts with the exception of 1909 and 1914 the infantile mortality rate in the north is lower than that for either the central or southern districts. The average infantile mortality rate for the inland districts varies irregularly from year to year, but the totals for the 10 years for the northern and central districts are practically identical.

A conclusive proof for the conception that infantile mortality is greatly influenced by many other factors is Graph XIV., which visualizes the decrease in infantile mortality for the three decades 1882 to 1911. The detailed Queensland infantile mortality tables prior to 1907 only record separate figures for death of children under two years of age. For the preparation of the graph the rates were calculated by utilizing the number of deaths under two years of age and the birth rate for the two successive years. For example, in 1882 669 children under two years died in the first coastal district. The number of births for 1881 and 1882 registered was 6,659. On calculating the rate a factor of 10.05 was obtained, which does not represent the true infantile mortality, but only represents an arbitrarily chosen figure for the infantile mortality. Similar calculations were carried out for the years between 1882 and 1911 and the average thus obtained graphically represented. The first column indicates the infantile mortality for 1882 to 1891, the second the infantile mortality from 1892 to 1901 and the third from 1901 to 1911 for the southern coastal district and so on. In this way graphs for the three coastal and the three inland districts were prepared, which indicate that the number of deaths of children under two years has decreased steadily from decade to decade, a greater relative improvement having taken place in the northern district than in either of the other two.

Comparison of the Rate of Births and Infantile Mortalities of Victoria, Tasmania and Queensland.

The average birth rates for Victoria, Tasmania and Queensland have been compared in Graph XV.. This graph shows that the birth rate is lowest in Victoria, highest in Tasmania, whilst Queensland occupies an intermediate position.

A comparison of the infantile mortality rate for the same States indicates that the total average infantile mortality rate for the three States over ten years shows only slight differences, although marked differences can be noticed for the individual years.

Conclusions.

For the purposes of a comparative statistical inquiry, Queensland, with the exception of the far north, a district extending from Port Douglas to Thursday Island, was divided into six districts, three coastal and three inland, situated in approximately the same latitude, representing southern, central and north Queensland. As a unit for comparison the decade between 1902 and 1911 was adopted, as the population figures could be considered fairly accurate on account of the census having taken place in 1901 and 1911; hospital admissions and hospital case mortality rates, district death rates and birth and infantile mortality rates were calculated.

(1) On the whole the average figures for hospital admissions to the northern hospitals were much higher than for the southern districts, but it could be proved that this fact is mainly due to an increased use of hospital facilities. On the whole, the average death rates are practically the same in the northern and in the southern districts. Average birth rates are approximately the same in all coastal districts, but are lower in the central and northern inland districts, which fact may find its explanation in the smaller number of women of child-bearing age.

(2) The average infantile mortality rate for the northern coastal district is lower than that for the central or southern district and is practically identical for the three inland districts.

(3) The statistical inquiry has proved that north Queensland, as far as vital statistics are concerned, does not differ essentially from central and south Queensland and compares favourably with Victoria and Tasmania.

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NOTES ON AUSTRALIAN *TABANIDAE.*

By Eustace W. Ferguson, M.B., Ch.M., and Gerald F. Hill, F.E.S.

The present paper is the outcome of correspondence between the two authors on the question of the identification of specimens of Australian *Tabanidae.*

One of us (E.W.F.), while in London, had the opportunity of examining the types of Australian *Tabanidae* in the Natural History Branch of the British Museum, and of comparing specimens with the types. In many instances the identifications were made by Miss Ricardo. Authentically identified specimens of many species were thus available, and these have been compared with such types as are in the collection of the Australian Institute of Tropical Medicine at Townsville.

The correspondence and comparison of specimens have revealed the fact that considerable synonymy exists among recently described species. Some of this is due to misidentification of previously described species, but much is due to too much reliance having been placed on slight variation in characters which can be shown, with long series, to be variable within the one species.

Incidentally it has shown that the groups suggested by Miss Ricardo for the division of the genus *Tabanus* are valueless, at any rate as applied to Australian species. The characters separating groups vii., viii., ix. and x. are entirely superficial, depending solely on clothing, so that the grouping of a species is dependent on the degree of abrasion of the specimen.

While the paper deals mainly with synonymy, one new species has been described, and the descriptions of one or two others have been held up pending the receipt of further material or information.

We should like to acknowledge the help we have received from Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, in comparing specimens with types in the British Museum.

Demoplatus nigrovittatus, n.sp.

Closely allied to *D. australis* Ricardo, but differing in colouration of the abdomen.

♂. *Face* brown, with yellowish-brown tomentum and rather sparse brown hairs; separated from cheeks by deep groove; cheeks similar; beard white. *Palpi* with second joint long, somewhat club-shaped as in *D. australis,* but black. *Proboscis* comparatively short. Antennae reddish-brown, second joint about half the length of the first; third joint apparently 8-annulate, but annuli somewhat indefinite and hard to distinguish, basal part somewhat wider than rest of joint, first and second joints with long dark hairs. *Eyes* contiguous, moderately finely faceted, bare. Ocelli present. *Thorax* dark brown, with brown tomentum and indistinct traces of 3 longitudinal tomentose vittae, the median darker, the submedian more yellowish in anterior half, darker posteriorly, the lateral margins with similar yellowish-grey tomentum; pubescence long and fine, greyish in colour, rather scanty, denser posteriorly and above wing roots. Sides dark brown with long, silky, light grey pubescence. *Scutellum* dark brown, with long grey pubescence. *Abdomen* reddish, with a moderately broad, median, black vitta extending the length of the abdomen, and somewhat expanded on first segment; lateral borders with black markings on 3-6 segments; pubescence light brown, with traces of creamy on the segmentations. Venter of a lighter reddish-yellow colour, without any black vitta; with fine greyish pubescence and a fringe of shorter fine creamy pubescence along posterior margin of segments. *Legs* reddish-yellow, tarsi with apical joints infuscate; posterior tibial spurs rather short. *Wings* clouded with brown, most marked along the anterior border and along the cross veins; distribution of shading similar to *D. australis*, but darker. *Length*, 11.5 mm.

Hab.—N.S. Wales: Kendall. (Miss M. Henry.)

Described from two males caught on flowers in garden on 26th February and 18th March, 1920. Both specimens have the wings damaged at the tips, and it is uncertain whether the first posterior cell is closed or open; but it is probably open as in *D. australis*. Apart from the colour of the abdomen, which is most striking, the species can be separated by the structure of the 7th tergite. In *D. nigrovittatus* the apical border of this segment is practically truncate, while in *D. australis* the margin is strongly bisinuate, the median portion being produced in a strongly rounded lobe. The antennal annulations are hard to distinguish, in this respect resembling *D. australis*, though the shape of the annulations is slightly different in the two species.

Type in Australian Museum, Sydney.

SILVIUS INDISTINCTUS Ric.

Ricardo, Ann. Mag. Nat. Hist., (8), xvi., (1915), p. 262; *S. hilli*, Taylor, Proc. Linn. Soc. N.S.W., xl., Pt. 4, 1915, p. 806; *S. borealis*, Taylor, *loc. cit.*, p. 809.

Specimens of *S. indistinctus* Ric. were determined by Miss Ricardo, and are unquestionably the same as *S. hilli* Taylor, a series of which has been examined by both authors, and the type by one of us (G.F.H.). Mr. Taylor was probably misled in his identification of *S. indistinctus* (Proc. Linn. Soc. N. S. Wales, 1916, xli., Pt. 4, p. 753) by a specimen so identified by Mr. Austen and quite distinct from the species as identified by Miss Ricardo herself.

The species is a variable one in the colouration of both thorax and abdomen and in the presence or absence of the median abdominal spots.

The type of *S. borealis* has also been examined and, though there appears to be a very slight difference in that the callus is less bulbous, we cannot regard it as other than conspecific with *S. indistinctus* Ric.

SILVIUS NOTATUS Ric.

Ricardo, Ann. Mag. Nat. Hist., (8), xvi., 1915, p. 264; Taylor, Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 43; *S. psarophanes*, Taylor, *op. cit.*, xlii., Pt. 3, 1917, p. 520; ? *S. fuliginosus*, Taylor, *op. cit.*, xl., Pt. 4, 1915, p. 810.

This appears to be a very widespread species and to a certain extent variable. Among our specimens is one from Sea Lake, Mallee District, Victoria, which was compared with the type (E.W.F.) from Kalamunda, Western Australia, in the British Museum.

We associate with this specimens from Lake Hattah, Victoria; Narrabri, N.S. Wales; and Springsure and Burnett River, Queensland. The New South Wales and Queensland specimens show some slight difference in that the forehead is slightly narrower and the antennae are rather lighter. The Burnett River specimens (♂, ♀) were bred out by Miss Bancroft and bear a label:—"Bred from larvae found in wet sand at river edge, Burnett R., 18.11.19." They are in excellent preservation, and the abdominal clothing is much more marked than in our other specimens, in which it is somewhat abraded. Through them we were able to associate *Silvius psarophanes* with *S. notatus;* the former species being identified with the Burnett River male. Males and females of *psarophanes* have also been bred out in Townsville (G.F.H.) and correspond with the Springsure and Burnett River specimens.

S. fuliginosus Taylor, of which we have examined the type and compared it with our series of *S. notatus,* appears hardly separable. It is somewhat smaller and the forehead is distinctly narrower than in the Victorian specimens, in which respect the New South Wales and Queensland specimens are intermediate. The antennae and legs are decidedly lighter in colour than in the Victorian specimen, but here again it is linked up by the intermediate specimens. We are inclined to regard it as not being specifically distinct, though it may be necessary to retain the name as a subspecies. Further specimens from the Northern Territory will probably be necessary to settle the status of *S. fuliginosus.*

SILVIUS SORDIDUS Taylor.

Taylor, Proc. Linn. Soc. N.S. Wales, xl., Pt. 4, 1915, p. 808; *S. tabaniformis* Taylor, *loc. cit.,* p. 813.

We have examined the types of Taylor's species and other specimens from the same district (G.F.H.), and cannot find any valid reason for maintaining them as distinct. The type of *S. tabaniformis* has more conspicuous clothing, but the type of *S. sordidus* is certainly considerably abraded. The colour of the abdomen is somewhat lighter in *tabaniformis,* but the type is apparently an immature specimen.

In his description, Taylor states that the inner margins of the eyes in *S. sordidus* are parallel, while under *S. tabaniformis* he states that the inner margins are slightly convergent towards the base. The difference, however, when the two types are compared is inappreciable.

TABANUS LEUCOPTERUS van de Wulp.

Van de Wulp, Tijdsch. voor Entom., xi., 1868, p. 98; *T. griseohirtus,* Taylor, Proc. Linn. Soc. N.S. Wales, xli., Pt. 4, 1916, p. 753.

This species was originally described from the Aru Islands, and a specimen in the collection of the South Australian Museum from Stewart River, Queensland, was determined by Miss Ricardo. This has been compared with a series of *T. griseohirtus* Taylor, including the type, and the species are certainly identical. The series shows some variation in size and in the colouration of the clothing, a specimen from Kimberley perhaps representing a variety, but too closely allied to be separated. The species appears to be widespread in the north of Australia and in the islands immediately to the north.

TABANUS PALLIPENNIS Macq.

Macquart, Dipt. Exot., Suppl. 1, 1844, p. 160; Ricardo, Ann. Mag. Nat. Hist., (8), xiv., 1914, p. 397.

A species of *Tabanus* from the Burnett River District, Queensland, bred out from larvae by Miss Bancroft, is tentatively referred to *T. pallipennis*.

Following is a detailed description of the specimens:—

A moderately small species with three well-defined abdominal vittae.

♂. Face rather deeply sunken, black, densely clothed with grey tomentum and with white pubescence; cheeks with grey tomentum and pubescence; beard grey. Palpi with second joint short, oval, creamy yellow, with mixed grey and black pubescence. Antennae brown, the basal joints more greyish; first joint broader and partially concealing second joint, the latter small, somewhat crescentic, both joints with a few, short, black hairs at apices; third joint rather slender, the basal portion angulate but hardly toothed above. Eyes large, contiguous for greater portion of length, separated below to allow of the appearance of a small strongly nitid black callus; the upper two-thirds of the eyes set with moderately large facets, the lower third with much finer facets.

Thorax black with median, submedian and sublateral grey tomentose stripes, clothed with black erect pubescence and with rather scanty, decumbent, golden pubescence on the grey stripes; sides clothed with grey tomentum, with long, fine, pubescent tufts, mingled dark and grey. Scutellum dark brown with slight reddish tinge, with black pubescence on dorsum and rather scanty, golden hairs along free margin.

Abdomen dark brown to black, with three vittae of elongate, pale grey, somewhat creamy spots, the segmentations also narrowly edged with same colour; median vitta extending from third segment to apex, spots elongate, broader at posterior margins of segments, forming a continuous vitta; sublateral vittae extending from first segment to apex, the vittae more interrupted, the spots not reaching the anterior border of each segment and not triangular in shape; pubescence black, with a few creamy hairs on some of the spots. Venter dark brown, segmentations narrowly edged with grey, pubescence black, grey on segmentations.

Legs dark brown, tibiae lighter yellowish-brown, apical half of fore tibiae darkly infuscate, tarsi rather darker than tibiae, the anterior tarsi black; pubescence grey on femora and basal half of anterior tibiae, black elsewhere.

Wings rather dark grey, with whitish areas in centres of cells, only visible from certain directions against a black background, cross veins lightly suffused with brown; veins brown, stigma narrow, fairly conspicuous; appendix present.

♀. Resembles male in general appearance. Face not sunken, densely clothed with greyish tomentum and rather dense, whitish pubescence, cheeks similar, beard white. Palpi with second joint short, very stout, apex not produced but rather sharply pointed, yellowish brown, with short, mixed pale and dark pubescence. Antennae as in male. Forehead rather broad, distinctly wider at vertex than anteriorly, densely clothed with grey tomentum, with brownish tinge in places and darker on vertex, pubescence black in centre and above, shorter and creamy at sides; callus transverse, reaching eyes, black, tumid and shining, a second, round, black callus in centre of forehead, occupying about half the width. Eyes with facets uniform, bare. *Thorax* as in male. *Abdomen* with median vitta extending to first segment, with more distinct, creamy, almost golden pubescence on the vittae. Venter with fine black pubescence in centre of the segments, grey at the sides. Legs and wings as in male.

Dimensions: ♂. ♀, 12 mm.

Bred from larvae found in wet mud, Cattle Corner, Wingfield (60 miles from Eidsvold), November, 1919 (No. 1).

This species is related to *T. rufinotatus* Bigot, but differs in its broader form, and broader forehead with larger secondary callus, spotted wings, and in its general appearance. This species has been placed under *T. pallipennis* Macq., though it does not completely agree in all details; in Macquart's description there are said to be three calli on the front, the lower two contiguous and sometimes united; in the present specimens there are only two calli, unless the dark area on the vertex be regarded as a third callus, and the middle one is equidistant from the vertex and the lower callus. The wings also differ from the description; in *T. pallipennis* they are described as a little greyish, though the name *pallipennis* would indicate a whitish winged species. Under a lens the wings appear as described above, but in certain lights they appear decidedly pale and the dark spots around the cross-veins are not conspicuous. This pale appearance is more marked in a female recently received from Lake Hattah, Victoria (Nov., 1919—J. E. Dixon). It is possible that *T. pallipennis* Macq. is a distinct species, but until specimens are available agreeing completely with the description it seems preferable to treat these specimens as belonging to Macquart's species.

TABANUS DUPLONOTATUS Ric.

Ricardo, Ann. Mag. Nat. Hist., (8), xiv., 1914, p. 396; *T. parvicallosus*, Taylor (*nec* Ricardo), Proc. Linn. Soc. N.S. Wales, xlii., Pt. 3, 1917, p. 524; *ibid.*, Rec. Aust. Mus., xii., No. 5, 1918, p. 64.

This species has been wrongly identified by Taylor; we have specimens compared with the types of both Miss Ricardo's species, and specimens identified by Taylor and recorded above as *T. parvicallosus* agree with *T. duplonotatus*.

TABANUS INNOTABILIS Walker.

Walker, List Dipt. Brit. Mus., Part 1, 1848, p. 177; *T. dorsobimaculatus* Macq., Dipt. Exot., suppl. iv., 1850, p. 28; Ricardo, Ann. Mag. Nat. Hist., (8), xv., 1915, p. 273; *T. duplonotatus*, Taylor (*nec* Ricardo), Proc. Linn. Soc. N.S. Wales, xli., Pt. 4, 1916, p. 755.

As the species identified by Taylor as *T. duplonotatus* Ric. did not at all correspond with a specimen compared with the type (E.W.F.), specimens were sent to London (G.F.H.) and have been identified by Dr. G. A. K. Marshall as *T. innotabilis* Walker.

TABANUS APREPES Taylor.

Taylor, Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 56; *T. batchelori*, Taylor, *loc. cit.*, p. 58.

The types of the two species have been very carefully compared and we are unable to maintain them as distinct; the principal difference between them is that *T. batchelori* has the wings slightly clouded with brown along the veins, whereas in *T. aprepes* the wings are practically clear. A series from Burnett River, however, shows considerable variation in the amount of suffusion, and varies from specimens in which the wings are more strongly marked than in *T.*

batchelori to specimens in which the wings are clear. There is also considerable variation in the colouration of the abdomen, possibly depending on maturity, as all of the specimens are bred. Both types can be absolutely "matched" among the series.

TABANUS NEOGERMANICUS Ricardo.

Ricardo, Ann. Mag. Nat. Hist., (8), xv., 1915, p. 283; *op. cit.,* (8), xix., 1917, p. 219; *T. hilli* Taylor, Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 64; *T. fugitivus,* Taylor, *loc. cit.,* p. 61.

The determination of the above synonymy is based on the comparison by one of us (G.F.H.) of specimens identified by Miss Ricardo as *T. neogermanicus* Ric. with Taylor's types. Taylor has placed his species in two different groups, *fugitivus* in Group ix. and *hilli* in Group x., but the distinction between these two groups is often a matter of abrasion and the groups are not natural ones, in any case, from the description, *hilli* would appear to be wrongly placed in Group x., as the segmentations are described as greyish. A comparison of the two descriptions reveals no difference apart from differences in what might be described as shades of colour. The determination in regard to *fugitivus* was checked by the examination by both of us of a paratype which is absolutely identical with the specimens determined by Miss Ricardo.

TABANUS BREVIOR Walker.

Walker, List Dipt., 1, 1848, p. 188; *T. anellosus,* Summers, Ann. Mag. Nat. Hist., (8), x., 1912, p. 226; Ricardo, Ann. Mag. Nat. Hist., (8), xv., 1915, p. 279; *T. australis,* Taylor, Proc. Linn. Soc. N.S. Wales, xli., Pt. 4, 1916, p. 257; *T. crypserythrus,* Taylor, *op. cit.,* xliv., Pt. 1, 1919, p. 60.

This species has been misidentified in Australian collections. Specimens of *T. australis* sent to London (G.F.H.) have been determined by Dr. G. A. K. Marshall and Mr. E. E. Austen as *T. brevior* Walker. Examination of a short series of specimens of *T. australis* and *T. crypserythrus,* including specimens identified by Taylor, showed that the species were identical. The types of Taylor's two species have also been compared (G.F.H.).

TABANUS NEOPALPALIS, nov. nomen.

T. palpalis, Taylor (*nom. praeocc.*), Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 66.

The name of this species being preoccupied by an Indian species—*T. palpalis* Ricardo (Records Indian Museum, iv., No. vi., 1911, p. 212)—we propose the above to replace it. The name *T. milsoni* Taylor, is also preoccupied by *T. milsonis* Ricardo, but in this instance we understand that the name has already been altered by Mr. Taylor.

TABANUS NIGRIMANUS Walker.

Walker, List Dipt., 1, 1848, p. 183; *T. badius,* Summers, Ann. Mag. Nat. Hist., (8), x., 1912, p. 225; Ricardo, *op. cit.,* (8), xv., 1915, p. 285; ? *T. daphoenus,* Taylor, Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 54.

Comparisons of specimens of *T. daphoenus* Taylor with the descriptions of *T. nigrimanus* Walk., and *T. badius* Summers, leaves no doubt in our minds that Taylor's species is the same as Walker's. We have thought it better, however, to query the identification until a specimen of *T. daphoenus* can be actually compared with the type of *T. nigrimanus*.

TABANUS MINUSCULUS, nov. nomen.

Tabanus minor Taylor (*nec* Macquart), Proc. Linn. Soc. N.S. Wales, xliv., Pt. 1, 1919, p. 64.

A change of name is necessary for Taylor's species, as *T. minor* has already been utilised by Macquart (Dipt. Exot., Suppl. 4, 1850, p. 33) for a species from Patagonia.

TABANUS REGIS-GEORGII Macquart.

Macquart, Dipt. Exot., 1, 1838, p. 132; Ricardo, Ann. Mag. Nat. Hist., (8), xvi., 1915, p. 276; *T. spadix,* Taylor, Proc. Linn. Soc. N.S. Wales, xli., Pt. 4, 1916, p. 761; *T. brisbanensis,* Taylor, *op. cit.,* xlii., Pt. 3, 1917, p. 527; *op. cit.,* xliv., Pt. 1, 1919, p. 67.

We have compared a long series of *T. regis-georgii* with specimens of *T. brisbanensis* Taylor received from the Queensland Museum, and with the type of *T. spadix,* and are unable to discover any tangible differences. The species is a very variable one in the colour of the clothing, in the width of forehead and shape of callus.

The Tasmanian specimens referred by Mr. Taylor to *T. brisbanensis* are evidently the species described by one of us (E.W.F.) as **T. diemenensis,* distinguished by the facetting of the eyes in the male.

For our identification of *T. regis-georgii* we are relying on Miss Ricardo's determination of the species in the British Museum. At the same time it seems unlikely, though not impossible, that the range of our east coast species extends to King George Sound. On the other hand we have seen Victorian specimens. Should the species from King George Sound prove to be different it will be necessary to re-establish the name *T. spadix.*

DASYBASIS APPENDICULATA Macq.

Macquart, Dipt. Exot., Suppl. 2, 1846, p. 25, pl. 1, fig. 1; Walker, List Dipt., Pt. v., Suppl. 1, 1854, p. 267; Ricardo, Ann. Mag. Nat. Hist., (7), xiv., 1904, p. 350.

This does not appear to have been identified in Australian collections of Australian *Tabanidae* since it was first described, though Bigot has referred a second species from Chili to the genus.

We have specimens before us of a species that agrees fairly well with both generic and specific descriptions with the exception that there are the usual five divisions on the third joint of the antennae. The divisions are however, obscure and might readily be miscounted, and the base of the third joint is not angulate but somewhat swollen in the middle, corresponding in this respect to Macquart's description.

The species is allied to *Tabanus gentilis* Erichson, and *T. froggatti* Ric., but may be distinguished from both by the head being somewhat compressed antero-posteriorly so that the forehead is relatively shorter and broader than in these species.

Walker's notes on the genus are valueless, as he placed therein two species now referred to *Pelecorrhynchus* and some of the generic characters given by him are founded on these. Should our identification prove correct, the genus *Dasybasis* would have to sink as a synonym of *Tabanus,* as the species is too closely allied to *Tabanus froggatti* and *T. gentilis* to admit of separation, and these two latter species are connected by others with the more typical hairy-eyed species of *Tabanus.*

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*Description sent for publication to the Royal Society of Victoria.

STIBASOMA HEMIPTERA Surcouf.

Bull. Mus. nat. d'Hist. nat., Paris, No. 2, 1912, pp. 62-63.

This species seems to have been quite overlooked by recent workers in Australian *Tabanidae.* The type had the antennae broken when described, which leaves some doubt in our minds as to whether it is ascribed to the correct genus. On the other hand there are other instances where South American genera have been recorded also from Australia.

The description does not fit any species known to us.

[*Reprinted from 'The Annals of Tropical Medicine and Parasitology,'*
Vol. XV, No. 1, *April* 27, 1921]

NOTES ON SOME UNUSUAL BREEDING-PLACES OF *STEGOMYIA FASCIATA*, FABR., IN AUSTRALIA

BY

G. F. HILL, F.E.S.

From the Australian Institute of Tropical Medicine,
Townsville, Queensland

(*Received for publication* 1 *March,* 1921)

PLATE XV

Although generally regarded as a domestic species, there are several records of *S. fasciata* breeding in rot-holes in trees and in water-retaining plants; this habit, however, appears to have escaped notice hitherto in Australia.

On 20th January, numerous larvae and pupae of this species and of *Ochlerotatus notoscriptus*, Skuse, were collected from a tin containing about 5 inches of water and a quantity of decaying leaves, which was found in the dense scrub 600 yards distant from the nearest of several seaside dwellings on Magnetic Island. Several adult *Stegomyia* which were captured at the same time (1 p.m.) while attempting to bite, and others which were bred from the larvae and pupae, were noticed to be distinctly darker and smaller than the forms found throughout the year in the Institute buildings. In order to determine the permanency of this dark form, a number of these males and females were bred from for five generations under the usual laboratory conditions, and concurrently with an equal number of generations from individuals of the lighter coloured form commonly found in dwellings. From both series males and females of each generation were secured for comparison, the experiment being terminated, in the case of the dark form, with the sixth generation, which comprised males only. An examination of the material thus obtained showed that the light form bred true, *i.e.*, the individuals of each generation did not differ from their progenators, whilst the dark form produced, in each generation after the first, a proportion of individuals of both forms, as well as intermediate forms. In both series some variation was noticed in the shape and width of the outer lyre-shaped thoracic ornamentation and in the length and width of the median thoracic stripes, but in none were the latter entirely absent, a character recorded by Taylor (1914).

The island referred to above lies in Cleveland Bay, about four miles distant from Townsville, and was formerly utilised as a site for the port Quarantine Station.

On 5th May, a considerable number of mosquito larvae were siphoned from a rot-hole in a poinciana tree (Plate XV), growing in the Hospital grounds and distant about 70 yards from the nearest dwelling. In addition to *Macleava tremula*, Theobald, and *Ochlerotatus quasirubrithorax*, Theobald,* this collection produced a large number of *Stegomyia fasciata*, similar in size and colouration to the Magnetic Island form. On 7th September, another batch of larvae and pupae were collected from this hole, and from them about one hundred adults were bred. In this case the males were of about the average size, but quite as dark as any I have seen, whilst the females were of the light form and unusually large.

REFERENCE

Taylor, F. H. (1914). *Proceedings of the Linnean Society of New South Wales.* Vol. XXXIX, p. 455.

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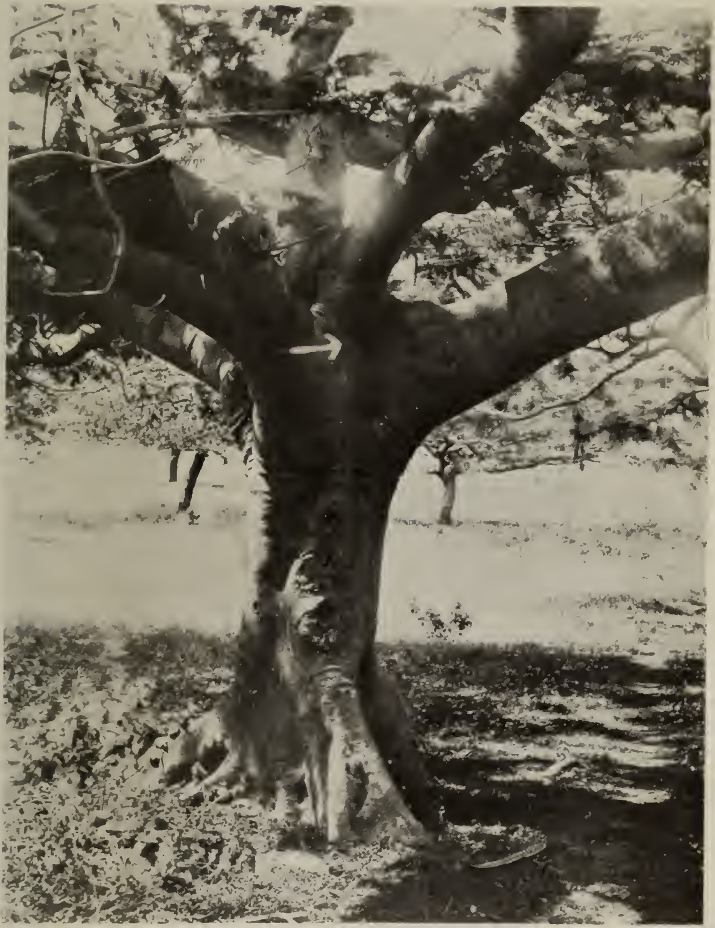
* Identified by Mr. F. W. Edwards, as a variety of this species.



ROT-HOLE IN POINCIANA TREE.
BREEDING PLACE OF *OCHLEROTATUS QUASIRUBRITHORAX*,
MACLEAYA TREMULA AND *STEGOMYIA FASCIATA*

C. Tinling & Co., Ltd., Imp.

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[*Reprinted from* ‘*The Annals of Tropical Medicine and Parasitology*, *Vol. XV*, *No.* 1, *April* 27, 1921]

MUSCA DOMESTICA, LINN., AS A ‘BUSH FLY’ IN AUSTRALIA

BY

G. F. HILL, F.E.S.

From the Australian Institute of Tropical Medicine,
Townsville, Queensland

(*Received for publication* 1 *March*, 1921)

In the literature dealing with the etiology of *M. domestica*, I can find no record of this species in the rôle of a ‘bush fly,’ *i.e.*, a fly which lives and breeds normally beyond the range of human habitations, although I understand that Major E. E. Austen is of opinion that this species originated in the tropics and has thence spread to temperate climates, where it is only able to maintain itself by the fact that it has taken to living in houses.

In two widely separated localities in North Australia, evidence has been gathered which strongly suggests in one case, and proves conclusively in the other, that this ubiquitous species is not dependent upon human habitations and environments for its existence.

During the period 1913-1917, specimens were frequently captured in the Darwin District (Northern Territory) on stock and carcasses at distances up to a couple of miles from dwellings, but for some time it was considered probable that these flies were bred under the usual conditions; later, however, examples were captured in company with *Musca ventrosa*, Wied. (*M. nigrithorax*, Stein.), and *M. humilis*, Wied. (*M. vetustissima*, Walk.) on the carcasses of freshly skinned buffaloes which had been shot in scrub country from three to six miles distant from the nearest habitation—a cattle station sixteen miles distant from the next nearest dwelling and about thirty miles from Darwin. During the summer months, *M. domestica* were very numerous at the station, especially in the kitchen and adjacent living room, but they were not seen on men or horses after leaving the homestead for the haunts of the buffaloes.

In April, 1919, an officer of the Stock Department, Townsville (N. Q.), brought in for identification a large number of flies which had been captured in the vicinity of a slaughter-yard and upon stock grazing in the locality, in some cases more than a mile from the nearest dwelling. This and later collections invariably included a large proportion of *M. domestica.*

During the months of April to October, flies of the same species were frequently captured upon grazing horses and cattle, and upon my face, hands and clothing in the Town Common at distances up to two and a half miles from habitations. On these occasions they were generally associated with *M. lusoria*, Wied.[1] (*M. australis*, Macq.,[2] *M. fergusoni*, J. & B.[3]), and *M. nebulo*, F.[4], (*M. hilli*, J. & B.[5]), the last named being less aggressive than the others. From October to about the end of March, *M. humilis*, Wied.[6] (*M. vetustissima*, Walk.) is the predominant species, and is certainly the most widely distributed *Musca* found in Australia, being as plentiful in the outer suburbs of Melbourne (Victoria) as it is in Central Australia, N. Territory, and the N.W. and Kimberley Divisions of W. Australia.

In the bush or open grazing country near Townsville, *M. domestica* oviposits on fresh horse-droppings, but they will also oviposit and rear their progeny on decaying vegetable matter, as shown by the fact that upon two occasions I have bred adults from full-grown larvae taken in nests of the Black-throated Grebe (*Podicipes novae-hollandiae*), which had become stranded upon the margin of a swamp, and in which the eggs had not yet hatched. The same nests and, also, small accumulations of drift, *i.e.*, leaves, horse- and cow-droppings, etc., blown up upon the margins of swamp, served as breeding-places for *Stomoxys calcitrans* and *Sarcophaga* sp.

Major E. E. Austen, who kindly examined the specimens of *M. domestica* from bush localities in N. Territory and N. Q., determined the latter as a variety of the typical form. Evidently the distincion is a very fine one, since recently I have examined a much longer series than was available to that worker, and I have compared them and their larvae with typical forms (from town dwellings) and their progeny, without being able to detect any variations peculiar to one series.

---

(1), (4), (6) Identified by Professor M. Bezzi.

(2) Identified by Major E. E. Austen.

(3) Johnston, T. H. and Bancroft, M. J. *Proc. Roy. Soc. Queensland.* Vol. XXXI, No. 12.

(5) Johnston, T. H. and Bancroft, M. J. *Mem. Queensland Museum.* Vol. VII, pt. 1. 1920.

COMMONWEALTH OF AUSTRALIA

Institute of Science and Industry

BULLETIN No. 21

The
WHITE ANT PEST
IN
NORTHERN AUSTRALIA

By

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Published under the authority of

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The White Ant Pest in Northern Australia,

Being some Preliminary Observations on Mastotermes Darwiniensis and Other Termites (White Ants).

By Gerald Hill, F.E.S.,

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1. INTRODUCTION.

The publication of the results of investigations made into the Termite life of the Northern Territory has been deferred for some time in the hope that the subject might be dealt with later in a more comprehensive manner. As much of the systematic work is still unfinished, it has been considered advisable to publish some preliminary notes on a few of the common species in the hope that they will serve to stimulate greater interest in the study of the Australian Termitidæ, and draw attention to the seriousness of their depredations.

Few of the more important groups of insects have attracted less attention from Australian entomologists than have the Termitidæ ; it is not surprising to find, therefore, that the literature on the subject is comparatively scanty and very largely the work of one author. By comparison with many other families of insects, the number of Termite species is small, and so distributed that it is generally a difficult matter to gather more than a few species in any one locality, and these often with the expenditure of much patience and physical exertion. As few entomologists have the leisure and opportunities for systematic collecting and observation, the study of Termites has not been a favorite one ; hence it is that there does not exist at the present time a single representative collection of Australian Termitidæ, and but little is known of the distribution and biology of even the commonest species.

Were it possible to estimate the direct and indirect loss due to the ravages of Termites in Australia, and particularly in Northern Australia, it would probably be found that these insects hold a place unrivalled by any in economic importance. That they have influenced the progress of development in the Northern Territory to a certain degree will be apparent to the most casual observer ; indeed, much evidence in this direction may be found within the municipal boundaries of the capital town—Darwin.

Were destruction confined to buildings, fences, plants, and a variety of other organic matter in this circumscribed area, means would doubtless be found by which this pest could be kept more or less under control. Unfortunately, however, Termites are widely distributed throughout the timbered and scrub covered areas of the Territory. In many localities the effects of termite activity are such as to justify the most exhaustive scientific investigation of the biology of the destructive species, and, indeed, of all species, as offering the best prospect of acquiring such knowledge as may lead to the discovery of means of lessening the heavy annual toll taken by them.

Some idea of the extent and nature of the ravages due to Termites in the northern portion of the Territory may be gathered from facts recorded in the following pages. From them, too, it will be seen that, apart from Government Departments and consequently the taxpayer generally, the most important section of the community, *i.e.*, those with more or less permanent interests in the country, have borne and will continue to bear the burden so long as the present deplorable condition continues.

Wherever Termites are indigenous or have become established the problems connected with their control have been full of difficulties, and it is questionable if any entirely satisfactory methods of dealing with them have been devised in any part of the tropics. From what is known of the biology of the most destructive Australian species, one may confidently express the opinion that anything less than the whole-hearted support of the Government, the co-operation of residents of the affected areas, and the best efforts of experienced investigators will not lead to results of any practical value. The difficulties to be overcome are very considerable, and this fact should be recognised at the outset. The cryptic and varied habits of these insects render investigation extremely difficult. A knowledge of the biology of the more important species is an essential to successful methods of control, and this knowledge is not likely to be gained in a cursory investigation. Further, a practical application of this knowledge, when acquired, is by no means free from difficulties, and it is here that biologist, chemist, and agriculturist must collaborate in devising means of combating the pest in a practical fashion.

That much of the present annual loss could be obviated if known methods of control and protection were more widely applied can scarcely be doubted, but there are many phases in the economy of Termites which, in the present state of our knowledge, render remedial measures ineffectual or unpracticable. The protection of wooden buildings, sheds, &c., is possible, and is frequently effected, more or less simply, by various methods; but the protection of fencing on a large scale, and more especially of growing plants, offer far greater difficulties. The frequent failure of so-called termite-proof buildings will be discussed in more detail at a later stage. Suffice it to say here that these failures are generally due to structural defects, faulty material, or neglect of ordinary precautions.

2. THE POSITION OF THE FAMILY TERMITIDÆ IN THE CLASSIFICATION OF INSECTS.

Throughout the English-speaking countries Termites are known almost universally as "White Ants," hence the erroneous popular belief that they and the true ants (Formicidæ) are more or less closely allied. Beyond the fact that both families are social and live in communities composed of several castes, including soldiers and workers, they bear few resemblances to each other which are not shared also by widely separated groups of insects. True ants have their nearest relations amongst the bees and wasps, and are all grouped in families within the Order Hymenoptera, whereas Termites or "White Ants" are now generally regarded as belonging to the Isoptera.

3. DISTRIBUTION.

Existing species of Termites are indigenous to the tropical and temperate regions of the globe, but it is in the former that they reach their maximum in number of species and destructiveness. In the present state of our knowledge it is impossible to state with any degree of accuracy the probable number of species indigenous to Australia. It may be said, however, that about 50 species have been scientifically described, of which number upwards of 17 are recorded from the Northern Territory. The latter number will probably be increased to 28 or 30 when the whole of the material now on hand has been critically examined. As collections have been made in only a few parts of Australia, it may reasonably be expected that many additional species await discovery.

4. ECONOMIC STATUS OF THE VARIOUS SPECIES.

For the purposes of this paper it is unnecessary to discuss the economic importance of all the species known to occur in the Northern Territory. Suffice it to say that comparatively few species are pests of the first importance, the remainder being either of only minor importance, harmless, or even in some instances beneficial.

The most injurious species are *Mastotermes darwiniensis*, *Coptotermes acinaciformis*, *Rhinotermes reticulatus*, *R. intermedius*, aad one or two undetermined species of *Eutermes*. Other species of less importance will be briefly referred to subsequently.

Certain species are occasionally indirectly injurious, amongst which may be mentioned the grass-eating species *Eutermes triodiæ*, which sometimes construct their great termitaria or mounds beneath telegraph lines, subsequently raising them to such height as to engage the wires. This species, and others sometimes construct their termitaria on seldom-used roads to the danger of wheeled traffic. Again, these mounds may be constructed on land intended for cultivation, in which cases, especially if the mounds are very large, the work of breaking them up and scattering such masses of intensely hard material is by no means easy, and subsequent crops do not thrive on the sites of such nests.

Amongst the harmless or possibly beneficial species may be enumerated those which gather and store in underground chambers dried grass, excrement, or other vegetable matter for food. By completely or partly destroying timber on land intended for cultivation some species are distinctly beneficial, but these species, being wood eaters, are potential pests of importance.

In many localities termitaria are a quaint and striking feature of the landscape. Such localities are found at Cape York (North Queensland), the Macarthur River (Northern Territory), and the sandy flats south of Darwin (Northern Territory). The last-mentioned place is the home of *Hamitermes meridionalis,* which construct the remarkable " meridional " or " compass " nests referred to by several travellers.

By far the most important species is the largest known Australian Termite —*Mastotermes darwiniensis*—which is distributed over a great area of North Queensland, Northern Territory, and the Kimberley Division of Western Australia. All other species sink to a position of minor importance by comparison with this. It is the species referred to in the following notes unless the contrary is expressly stated, and it is the species which must claim the most attention in any future research. How little is known of its biology may be judged from the fact that the true king and queen are still unknown.

5. BIOLOGY.

The biology of Australian Termites is so imperfectly known that it is impossible to discuss the subject in detail in the light of present knowledge. For most of our knowledge we are indebted to the work of Froggatt, whose monograph, written in 1895–1896, and supplemented in subsequent papers, remains the only comprehensive contribution to literature on the subject.

The known habits of the various genera, and of species within well-defined genera, differ in such a marked degree that it is impossible within the limits of this paper to discuss more than a few species, and these somewhat briefly.

A. Mastotermes darwiniensis, Froggatt.

Mastotermes darwiniensis, the largest, most destructive, and possibly the best-known termite, has its nearest allies in the Sub-family *Calotermitinæ,* of which there are few known representatives in North Australia. Some idea of the diverse habits and remarkable instincts of this species may be gathered from the facts recorded in this paper. That many other termites exhibit similar or somewhat similar habits and instincts is well known, but in none of those known to the writer are they developed to the same extent in any one species.

As a general rule a community of *Mastotermes,* for example the inhabitants of an infested fence post, will be found to comprise adult individuals of two castes, *i.e.,* soldiers and workers, the former numbering about 4 per cent. to 20 per cent. of the total. In addition, there are generally present a number of immature workers approximating the adults in size. Rarely there may be present a few very young worker larvæ and even soldiers in the stage preceding the adult, *i.e.*, possessing soft, creamy-white heads and jaws. As is the case in all other species of Australian Termites, neither of these castes possesses eyes, compound or simple, they depend upon other senses to enable them to carry on the functions of their respective castes. The workers alone are responsible for the havoc wrought by their species, and it is they who tunnel in the soil, or timber, construct the covered galleries, and prepare and mould the cement-like material used in sealing up cracks and crevices and repairing damaged workings. They, too, assist the soldiers in the defence of the community against the attacks of ants and other enemies. In all probability they alone feed and attend the young, the soldiers, the winged adults, and the royal pair or supplementary royalties, whichever may be at the head of the colony (it has been stated previously that true kings and queens of this species have not been recognised).

If the post is encircled by a deep trench it will be found that one or more tunnels leading to it are intersected at varying depths. From the nature of the individuals found in these tunnels and within the post it is evident that the community is only an outpost of the main colony, which is never located in a mound, but always lies concealed beneath the surface. If an attempt be made to follow one of the intersected tunnels back to such nest the investigator is assured of a long and laborious task, invariably, in the writer's experience, ending in failure. Either the course of the tunnel is lost, or it dips down to a depth below which further excavating is impracticable, or it extends beneath some obstacle which bars further progress. The maximum distance from the nest at which these termites feed is not known, but it certainly exceeds 100 yards. The erratic course and varying depth of the tunnels below the surface and the fact that numerous similar tunnels are frequently intersected add greatly to the difficulties of investigation.

Sometimes a nest is found within a post or dead tree. In such cases that portion of the wood lying beneath or just above the surface of the ground is almost entirely replaced by tier upon tier of horizontal chambers constructed of comminuted vegetable matter moulded to form cells of varying size, but always very large by comparison with the cells found in the nests of other species (Plate 1). These are occupied by similar individuals to those already referred to, in addition to others differing greatly from them, namely, great numbers of perfect winged males and females, or the nymphs which are destined to develop into these winged forms, and also a few individuals derived from nymphs in the stage preceding the appearance of the wing rudiments or wing buds. In the latter there is no evidence of the wing buds characteristic of the nymph in which development has not been arrested and diverted. They are smaller and much darker, possess a harder integument, and are more active. They are the complementary forms, which may, under certain circumstances, become productive without having acquired the wings of the perfect males and females. Royalties derived from these complementary forms are known as neoteinic or supplementary kings and queens, as distinguished from true kings and queens, which are derived from the perfect winged males and females.

The nymphs of the winged forms are found in the nest from January or March onwards. Their development is slow until about October or November, when they undergo a moult, from which they emerge, still as soft-bodied, white insects, but having large, soft, wrinkled white wings. Subsequent development is rapid. The integument becomes dark and hardened, and the large, stiff wings, which enable them to swarm from the nest, are acquired without a further moult. Late in November or during December or January, and after the first heavy rains of the season, these winged forms swarm from the nests on their first and only flight. After travelling a short distance they settle upon the gound, where the wings are broken off at the basal cross suture. Mating and the formation of a new colony have not been observed, but certainly take-place after the shedding of the wings.

In two instances nests discovered after swarming were found to contain a few winged adults with two or three of the wings missing or mutilated. Whether these individuals were retained by the colony to become the parents of future broods, or whether they were there from sheer inability, owing to their damaged condition, to take part in the swarming, is not known.

Judging by what is known to occur in many other species such a nest should contain a true royal pair, or, at any rate, a true queen. Such, however, have not been found in the nests examined by the writer, nor is there any published record of their occurrence. It is certain that the vast majority of the winged adults which leave the parent colony perish before they become reproductive, but it is inconceivable that none survive to become the future kings and queens of new colonies, or that the species is reproduced solely by the neoteinics referred to above. It is more feasible to suppose that the true queen in *Mastotermes* retains, excepting for her wings, much of her pre-nuptial appearance, instead of attaining the proportions of the queens in other species. If this supposition be correct, failure to discover a queen *Mastotermes* is quite understandable, especially if the nest contains winged adults. Once a nest is disturbed the thousands of individuals occupying it are thrown into the greatest confusion, and soldiers and workers alike blindly attack each other and all other members of the colony. This confusion and the difficulty of making a careful examination are greatly accentuated by the attacks of hordes of ants (*Iridomyrmex detectus*) which almost invariably rush to the scene, attacking termites and investigator with remarkable ferocity.

There is evidence to support the belief that some of the smaller colonies investigated were originally outposts, comprising workers and soldiers from a larger colony, who, finding themselves more or less detached from the parent nest, had brought into use neoteinic kings and queens, which subsequently became the progenitors of larvæ nymphs and winged adults. Such a phenomenon is known to exist in the European *Calotermes flavicollis*, and might reasonably be supposed to have a parallel in *Mastotermes*. An analogous condition certainly does obtain in at least one Australian Genus (*Hamitermes*), in one species of which egg-laying neoteinics are the rule and true queens the rare exception, notwithstanding the fact that even moderate-sized colonies produce many hundreds of winged adults annually.

It has been stated in literature that *Mastotermes*, like *Calotermes*, does not construct regular nests, but forms small colonies under logs, in stumps, posts, and dead trees. Unfortunately, these statements are inaccurate, and convey an entirely misleading idea of the life-habits of the species. The nests have been referred to in the preceding pages ; it may be of interest to refer now to the number of individuals found in them. In the smallest nest examined by the writer the population was roughly estimated to exceed eight or ten thousand individuals, and in the largest the number was probably nearer one million. That the latter colony was not of the maximum size is shown by the following statement communicated to the writer by an observant resident of the Northern Territory :—" The termites made their way through the concrete floor, which was of poor quality, ' clayed ' together 20 drums of benzine and 25 cases of kerosene, destroying most of the pine boxes. Two gallons of worker and soldier termites were gathered in cleaning up the *débris*, after which boards were laid over the holes in the floor as traps. Every morning from 23rd November to 4th January the boards were lifted and the termites, which had congregated under them overnight, were swept up and measured in quarts and pints. During this period the catch totalled 83 pints, which, by measuring and counting a given bulk, was estimated to comprise nearly a million individuals, exclusive of the 2 gallons gathered before trapping was commenced. In the adjoining room similar trapping operations had been carried on for three months, but no record was kept of the number caught. It was thought that both rooms were invaded by the members of one colony. Trapping did not exhaust the supply of soldiers and workers." Obviously trapping would not directly affect those forms which do not take part in food-gathering operations, *i.e.*, larvæ, nymphæ, and winged adults, which would probably equal the soldiers and workers in number. Remarkable as these figures are, the present writer is satisfied of the approximate accuracy.

With the exception of a few species of *Calotermes* and *Glyptotermes*, it appears to be an invariable rule among Australian Termites that there must be uninterrupted communication between the source of food supply and the ground, or, in the case of the arboreal species of the genus *Eutermes*, between the nest or termitarium and the earth. Hence we find workers and soldiers, that have passed upwards from a house block or pile into the floor joists of a building, will soon perish if communication with the nest is prevented by means of an effective stump cap or other device. Sometimes a temporary covered-way is constructed around the cap and down the exterior of the pile to enable the isolated individuals to return to the ground and the nest ; but generally they are thrown into a state of confusion, wander about in an aimless fashion until they fall victims to predaceous ants, lizards, or other enemies.

Small colonies of *Calotermes* and *Glyptotermes* spp. have been found in the stems of trees and shrubs in which there was no internal passage to the ground and no covered-ways on the exposed surfaces, but this habit is unknown in any other genera.

The necessity in most species for communication with the ground doubtless accounts for the fact that there is no authentic record of a colony having originated from any of the thousands of winged males and females which are so often attracted to lights within doors.

In the construction of termitaria, covered-ways, and other operations involving the use of woody or earthy matter, a comparatively large quantity of moisture is employed. The building material is carried in the jaws in a condition susceptible of being moulded, and when laid in position is moistened further with saliva or fluid matter regurgitated from the stomach. The tip of the body is then brought into contact with the plastic mass, and the final moulding effected concurrently with the excretion of a copious flow of muddy fluid from the intestinal paunch.

From whence this moisture is derived in the case of species inhabiting the arid interior or the coastal sand-hills is not known from actual observation, but in *Mastotermes* it is probably obtained largely by tunnelling deeply into the soil. In endeavouring to follow underground passages from an infested post back to the nest one has found a tunnel to dip nearly vertically from a few inches below the surface to a depth of 4½ feet, where further digging was abandoned. In another instance during road excavating a vertical tunnel was encountered at 14 feet below the surface, and in another a vertical covered-way was built down the side of a well-shaft to a depth of 11 feet, at which level the sides were moist. In all three instances food was not the object in view, and in the last this was most evident since the covered-way commenced at 4 feet below the surface, where the earth and broken rock formation gave way to solid rock. Apparently the termites had penetrated elsewhere to the impervious rock, and, finding further downward progress impossible, had driven horizontally to the well-shaft.

B. Eutermes.

The genus *Eutermes* includes a large number of species all of which have soldiers of a type differing remarkably from those of all other Australian genera. Contrary to the general rule, the soldiers in *Eutermes* are smaller than the workers, and in numbers approximate the latter caste more closely than do the soldiers of any other genus. The shape of the head varies slightly in the different species, but it is always rounded behind and produced anteriorly to form a long symmetrically tapered snout, terminating in an opening connected with a large chamber in the posterior half of the head. The jaws are rudimentary and useless as a means of defence. For courage and efficiency in the protection of the community from the attacks of predators the *Eutermes* soldier has few, if any, equals amongst Termites. If the walls of the termitarium or the underground galleries are broken so as to expose the community to the attacks of ants, they immediately crowd to the most advanced positions, from which point of vantage they eject from the tip of the snout a clear viscid fluid. The effect of this fluid upon the invading horde of *Iridomyrmex* is invariably the same—the ants are rapidly driven off or left hopelessly enveloped in the secretion and adherent particles of earth. In the meantime the workers temporarily repair the breaches, and the soldiers gradually withdraw to the protection of their nest or gallery.

The feeding and nesting habits of *Eutermes* differ greatly in the various species. Some are very destructive to timber, others live exclusively on grass, and others upon vegetable *débris*, such as decaying leaves, excrement, and matter found upon the surface of the soil. Many species invariably build mounds, which serve as domiciles for the community and store-houses for their food, while others are found in tunnels and small chambers in the ground, or in more or less spherical, fragile nests in the forks of trees.

Amongst the mound builders the most remarkable species is the so-called Spinifex Termite (*Eutermes triodiæ*), the nests of which are said to exceed in size those of any known Termite. The largest termitarium actually measured by the writer was 20 feet in height and 12 feet in diameter 2 feet from the ground. The whole structure is formed of particles of sand, earth, and grass cemented together with salivary and proctodæal matter. In large nests a considerable portion of the base is nearly solid, the original galleries and chambers having been filled with waste material from their colony. The interior consists of innumerable galleries and chambers connected with each other by small openings. Those near the walls are nearly always filled with grass cut into pieces about ¼ inch or more in length, while the inner chambers are occupied by the community. The queen cell is a large flattened chamber situated near the ground about the middle of the nest, and near it are found masses of eggs and young larvæ. The colony consists of immense numbers of larvæ, workers, soldiers, and nymphs, or, late in the year, winged adult males and females derived from nymphs. A true queen appears to be always present, but, except in very small nests, it requires much laborious pick and shovel work and patient searching to find her. In one instance, two queens were found together in a nest which was considered to be three or four years old ; but such a phenomenon is unique in the writer's experience of Termites, although two gravid neoteinic queens and one true king have been found in a queen cell of *repanotermes*. A true king of *E. triodiæ* was found in one instance only, and in this case the royal pair was domiciled in a termitarium about 9 inches in height and apparently one year old. Complementary royalties have not been found in *E. triodiæ* or any Northern Territory species of this genus, from which it must be inferred that these immense termitaria, obviously the result of many years of labour, are restocked from time to time with young adult males and females, or that they are presided over by the original queen for many years and long after the death of her consort. The large number of old and abandoned termitaria found in certain localities, and the fact that the queens found in all old nests are at or beyond their maximum fecundity, lend strong support to the latter hypothesis. Analogous conditions are found in other species of *Eutermes*, as well as in *Microcerotermes* spp. and *Coptotermes* spp., but in *Hamitermes* spp., *Mirotermes taylori*, and *Drepanotermes* spp. communities are perpetuated by neoteinic males and females or sometimes by a true king and one or more neoteinic queens.

The king, queen, and winged adults of *H. meridionalis* have not been found in the Northern Territory, notwithstanding the fact that many hundreds of the remarkable " compass " or " meridional " nests have been examined at intervals extending over a period of four and a half years.

6. DESTRUCTION CAUSED BY TERMITES, WITH OBSERVATIONS ON RESISTANT AND NON-RESISTANT PLANTS, TIMBERS, AND BUILDING MATERIAL.

The following examples of destruction caused by Termites are selected from the writer's notes as being typical of the damage being wrought daily throughout the termite-infested areas. These records are from personal investigation, excepting where otherwise stated, and cover but a fraction of the cases investigated.

A. Destruction of Growing Plants.—Certain Plants Immune from Attack in the Growing State.

Certain species of indigenous trees and plants are conspicuous owing to their immunity from attack; their number, however, is very limited if we exclude herbs, shrubs, and such trees as are affected by tidal waters, and which are periodically partly inundated. None of the latter produce timber of commercial value. Amongst the most striking trees which appear to enjoy total immunity from attack may be mentioned the so-called milkwood trees (*Alstonia verticillosa*), currajongs (*Brachychton suborbicularis*), bean trees (*Erythrina vespertilio*), and " chestnut " trees (*Canarium australianum*), all of which are distinctly ornamental trees, but have no commercial value.

Amongst introduced trees rubber (*Hevea brasiliensis*) appears to be immune, but it should be mentioned that a young plantation at Point Charles died out from causes unknown to the writer. Tamarind trees are probably immune. Tomatoes and many other cultivated plants are not molested by Termites. Many species of growing plants are subject to attack.

All of the indigenous trees known to the writer as producing timber of any economic value are subject to attack excepting a few comparatively rare trees which are found in the vicinity of some permanent springs. Many species of trees susceptible to attack when growing are more or less resistant when seasoned. These timbers will be referred to again later on in this paper. Many other indigenous trees, as well as root crops, sugar-cane, melons, fruit trees, cassava, papaya, granadilla, poinciana, sisal hemp, potatoes (English and sweet), coconuts (Plate 3), pineapples, &c., are frequently destroyed by Termites.

EXAMPLES OF DESTRUCTION OF GROWING PLANTS, WITH NOTES ON PREVENTIVE MEASURES.

The predominant forest trees of the Northern Territory are the eucalypts, various species of which produce the bulk of the indigenous timber used in fences, stockyards, country dwellings, outhouses, sheds, mining and well shafts, &c. Nearly all species of these trees are more or less subject to attack by certain kinds of Termites, the heartwood especially being destroyed by *Coptotermes* and occasionally by *Rhinotermes*.

Whatever the species of Termites be, the trees are attacked in the first instance below the surface of the soil. Subsequently the heartwood is entered, and destruction is carried up the trunk and into the main branches. The "pipe" thus made in the trunk may be of small diameter, or the damage may be extended until only a mere shell and the bark remains. Even in extreme cases there is often no external evidence of the presence of Termites. The shell, if sufficiently thick, yields (especially in woolly-butts and stringy-barks) very durable and nearly termite-resistant posts.

Coptotermes is responsible for most of this class of destruction, and sooner or later this is made evident, first by the appearance of deposits of earthy material carried up by the insects and used to cement up external cracks and branch holes, and later by the construction of a termitarium or nest at the base of the tree. With the increase of the colony the termitarium is enlarged to accommodate its numbers. The collapse of the upper part of the trunk and branches and the envelopment of the remaining portion within the termitarium follow rapidly, leaving the characteristic dome-shaped structure to mark the site formerly occupied by the tree.

E. grandifolia, when attacked by *Mastotermes*, presents features differing in a marked degree from the foregoing. Thus, after entering the trunk in the manner stated above, one or more tunnels, large enough only to permit of free passage up and down for the insects, are made in the solid wood, and carried upwards from 3 to 20 feet from the ground, then outwards to the cambium, at which point the trunk or branch, as the case may be, is cinctured by 4 or 5 to 20 or more deep sinuous grooves (Plate 4), which cause effective, though concealed ringbarking. With the growth of the tree the bark divides horizontally and gum exudes (Plate 5). To prevent the entrance of light and predaceous insects these crevices, as they widen, are sealed up with earthy material, which accumulates until this part of the trunk or branch is encased in a thin protecting sheath. The stoppage of the sap flow is followed by the shedding of the leaves and bark, and generally, if not always, by the disappearance of the Termites. Plates 5 and 6 illustrate such instances of Termite activity. Similar observations have been made with regard to certain undetermined indigenous trees found in so-called jungles in the vicinity of permanent springs, and also in mango trees. In the latter the Termites persist long after the tree is dead.

It appears to be the general belief that living trees are attacked only in the dry season for the purpose of obtaining moisture. It is not certain that this work is confined to any particular season. Moreover, it is evident that moisture alone is not the attraction, since the unidentified trees referred to above grow in soil so saturated with water that to traverse it on foot is often a difficult matter.

The wood of paper-bark or cajuput trees (*Melaleuca leucadendron*) appears to be immune from attack in the growing state, but the exterior bark is sometimes destroyed by an arboreal species of *Eutermes* and rarely by *Coptotermes*. In Queensland, however, the latter or a very closely allied species has been observed by the writer attacking the heartwood. In the dry state this timber possesses considerable termite-resisting properties, and, if sawn and seasoned, would probably yield a useful timber for floor joists, studs, rafters, &c. For fence posts, piles, &c., its life is generally short, owing to dry rot. A fairly abundant supply is available in certain localities in the vicinity of creeks, springs, and swamps. A smaller variety or species which is generally found on sandy flats associated with *Grevillea leucadendron* is said to be quite resistant to Termites.

Ironwood (*Pitheco obium moniliferum*) is generally recognised as the most durable timber for fence posts, house piles, and similar purposes. Unfortunately the supply of well-grown trees is very limited, and is now practically exhausted near settlements. In the growing state the heartwood is attacked by *Coptotermes* and *Mastotermes*, but rarely to such an extent as to render the trunks unsuitable for these purposes. In the dry state both heartwood and sapwood are sometimes destroyed by Termites, but injury ceases here, leaving a post or pile of remarkable durability.

Few indigenous trees are more susceptible to termite attack than *Grevilleas* of various species, and for this reason full-grown trees are rarely met with.

B. Cultivated Fruit and other Trees.

The principal fruit trees growing in the Northern Territory are mangoes, citrus, soursops, and custard apples, all of which are attacked by *Mastotermes*.

Mango trees, as previously stated, are attacked in a similar manner to *E. grandifolia*; destruction continues, however, until the greater part of the trunk and larger branches are devoured. Poinciana trees (ornamental) are similarly attacked (Plate 6). Citrus trees are, in most localities, attacked at an early age, and rarely attain a considerable size on this account. The mode of attack differs only in detail from that outlined in reference to mangoes. *Mastotermes* is the only species implicated as far as is known to the writer. The trunks, main and smaller branches are hollowed out before the presence of Termites is suspected, sterility and yellowing of the foliage usually being the first indications of infestation. Occasionally these symptoms are preceded by the bending and splitting of the branches, so weakened that they are no longer able to support the weight of the head. Such is the vitality of these trees that they rarely die as the result of termite infestation unless contributory causes are present, such as drought, massive coccid, fungus or bacterial infection. Frangipanni and ceara rubber trees also are attacked in this manner by *Mastotermes*.

It may be mentioned here that in Townsville, Queensland, where *Mastotermes* is frequently met with, coconuts, mango and frangipanni trees are rarely attacked.

C. Methods of Control and Prevention of Attacks on Growing Trees.

Several methods of control and prevention which were tried by the writer, may be grouped as under :—

(*a*) Soil fumigation.
(*b*) Soil poisoning.
(*c*) Poisoned baits.
(*d*) Fumigation of hollow trunks and roots.
(*e*) Injection of poisonous liquids into hollow trunks and roots.

(*a*) *Soil Fumigation.*—A number of experiments in which carbon disulphide was used as recommended for the destruction of vine phylloxera and apple-root borer (*Leptops hopei*) were carried out by the writer in 1913, but the results did not justify their continuance. The cost of this treatment is prohibitive, and the effects are not lasting.

(*b*) *Soil Poisoning.*—Experiments with arsenate of lead ("Electro" arsenate of lead paste, 1 lb. ; water, 16 gallons) gave excellent results when poured into a shallow trench opened out about the trunks of small trees in the early stages of attack. Similar methods proved equally effective in the treatment of infested ornamental shrubs and papayas. In all cases one application proved effective for about one year—the period during which the plants were kept under observation—and three applications during one year appeared to have no injurious effects upon plant life. In several other cases saturation of the soil with arsenate of lead solution appeared to be responsible for the immunity from attack of susceptible plants growing in termite-infested soil. Before this method of prevention and control can be recommended for general use much experimentation is required to determine—(1) the effect of repeated applications upon plant life ; (2) the minimum strength and number of applications required to insure effective results ; (3) the best period of the year for carrying out the operation, *i.e.*, before, during, or after the wet season ; and (4) incidentally, the effect upon other insect pests which pass the larval stage in the soil. (It may be mentioned that there are in the Northern Territory several potential pests closely allied to the well-known curculionid beetle *Leptops hopei*, of southern Australia.)

Bichloride of mercury (corrosive sublimate).—This salt is effective, but in the strengths experimented with there were evident signs of injury to plant life. Further experiments with weaker solutions should be carried out.

Several chemical fertilizers are recommended in the control of certain soil-dwelling pests, but only one of these, *i.e.* kainit, has been experimented with in the Northern Territory in connexion with Termite eradication. The results were distinctly unsatisfactory.

(*c*) *Poisoned Baits.*—Bran, softwood sawdust, and pine boards moistened with arsenical solutions and sweetened with sugar or molasses were placed in the soil near infested trees and timber; the results, however, were not conclusive. In one instance only did the bait (sawdust) prove attractive, and in this no definite conclusion could be arrived at. The poisoned food was placed under boards stacked on a concrete floor across which Termites had built their covered-ways to protect their approach to the timber. For a few days a small quantity of the bait was devoured, after which both timber and bait remained for some time untouched. This result appeared to be satisfactory, until it was found subsequently that other parts of the house and adjacent trees were badly infested by Termites from this or another colony. Inconclusive as these experiments were, they appear to justify further and more exhaustive experiments, especially where other means of control do not suggest themselves. The well-known habit, especially in *Mastotermes*, of devouring their dead offers a ready means of exterminating inaccessible or unlocated communities, once a satisfactory means of poisoning the foraging members of the colony is discovered.

(*d*) *Fumigation of Hollow Trunks and Roots.*—Although not an invariable rule, the trunks of most infested trees are more or less hollow. Provided that the trunks are more than about 2 inches in diameter and woody, a simple and effective means of preventing further damage has been fully demonstrated. A device known as the "White Ant Exterminator," consisting of an air pump and retort, connected by a flexible pipe and fitted with a flexible steel nozzle, is used in South Africa and Malay States to force the fumes of arsenic and sulphur into the underground tunnels of certain species of Termites. This machine has been used experimentally in the Northern Territory for the fumigation of the trunks of citrus, mango, and other trees, and for the fumigation of hollow piles, posts, &c., with success. There are no apparent ill effects upon plant life, and the treatment is lasting. The following method, however, is equally effective and less expensive.

(*e*) *Injection of Poisonous Fluids into Hollow Trunks and Roots.*—Many experiments in which a solution of arsenate of lead (1 lb. arsenate of lead, water 16 gallons) was injected into the hollow trunks of citrus, mango, and other trees proved this method to be thoroughly effective, lasting (for three years at least), and non-injurious to trees. A hole of sufficient diameter to take a small funnel or the nozzle of a syringe is bored into the centre of the trunk at a convenient height from the ground, and into this is poured a quantity of the fluid (8 oz. to several pints, according to the size of the tree and the extent of the hollow). The hole is then plugged with a hardwood plug, which is cut off level with the bark. In every case the bark overgrew the plug, and a marked improvement in the condition of the tree resulted.

Other arsenical sprays, such as Paris green, would probably prove quite as effective. Solutions of arsenate of soda and arsenical cattle dips proved to be more or less destructive to the plants. In a few cases (mangoes and large ornamental trees) difficulty was experienced in locating at the first attempt the hollow made by Termites, when it became necessary to bore two or more holes. Provided these holes are plugged as described above no ill effects follow. Excepting in the fluid used, this method is similar to that commonly employed in protecting piles, posts, &c., from termite attack. In the latter case arsenate of soda is generally used.

D. Destruction of Building Timber, Posts, &c.

All imported timbers known to the writer to be used in the Northern Territory for building or for fencing purposes, unless chemically treated, are readily attacked by Termites. Included in the above are the American and European softwoods, Western Australian jarrah and karri, Victorian messmate, and Queensland white pine. Tasmanian bluegum and Victorian redgum appear to be more resistant than any of the above.

Of the indigenous timbers of the Northern Territory suitable for piles, house blocks, fence posts, and similar purposes, ironwood (*Pithecolobium moniliferum*), bloodwood (*Eucalyptus terminalis*), smooth-stemmed bloodwood (*Eucalyptus sp. ?*), and large-leafed gum (*Eucalyptus grandifolia*) may be mentioned as being amongst the most durable, though none of them are absolutely resistant to Termites. In all cases the sapwood is freely attacked, and for this reason it should be removed from the lower parts of posts or piles to at least a few inches above ground level.

This precaution is not so necessary when ironwood is used, but it is distinctly advantageous in all cases where rails are mortised into the posts, since the sapwood provides a ready means of access to the less durable timber generally used for this purpose.

For split fence posts, rails, and rough dressed rafters, &c., mature "woollybutt" and "stringybark" are probably as durable as any local timber, and are usually readily obtainable. As previously stated, these trees are generally hollow as a result of termite infestation, and for this reason are of little use for bridge-building or similar purposes. Immature trees, say from 6–8 inches in diameter, are sometimes used in fencing, but such posts are generally destroyed by Termites within three to five years in badly infested country. Similar timber is frequently used for the uprights of rough farm and station buildings, but serious damage is almost certain to result, sooner or later, unless steps are taken to protect them from attack.

Undoubtedly the best local timber for sawn rafters, joists, flooring boards, light fence rails, &c., is cypress pine (*Callitris robusta*). This timber, when freed of sapwood, is practically termite resistant, but it is unsuitable for use underground or where great strength is required.* *Mastotermes*, however, will penetrate pine in order to attack more palatable material, as the following observations will show :—A number of mixed hardwood and softwood boards, which were stacked for safety on a deck of 2-in. cypress pine planks, were found to be practically destroyed by Termites. In this case about a dozen holes were made through the planks by Termites to enable them to reach the boards above. In another case the Termites passed through a defective stump cap, then through a 3 x 4 in. cypress floor joist and a 1-in. cypress flooring board to attack a bag of sugar.

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* An Australian species of *Callitris* is recorded as possessing a poison of unknown principle. The injurious effects upon the skin of saw-millers and others engaged in handling this timber are well known.

E. Methods of Rendering Fencing Posts, Piles, Building Timber, &c., Impervious to the Attacks of Termites.

Various chemicals, oils, and products of coal are recommended as more or less effective in preventing the depredations of Termites, but in most cases the cost of treatment is considered to be prohibitive, and for this reason, if for no other, the artificial treatment of building and fencing timber is not generally practised in the Northern Territory. House blocks and piles, however, are usually treated in some way, and there can be no doubt that any expense incurred in this connexion is amply compensated in the increased life of the timber and reduced risk to the building.

Zinc chloride and corrosive sublimate are thoroughly effective, but these chemicals are too costly for general use. The former is especially suitable (in 6 per cent. solution) for the treatment of wood which is to be painted, and the latter for dealing with localized attacks. A strong solution of alum in water is also effective, but owing to its solubility and cost its uses are restricted. Arsenic in some form or other is probably the most effective and cheapest poison in use for insect pest control. In the form of arsenate of soda it is particularly effective against Termites, and it is the active principle in most, if not all, effective " white-ant " specifics. Arsenate of lead has given very satisfactory results when used as a spray for floor joists and other similar work and as a poison for Termites in hollow posts.

Wood-preserving oils, creo-tar oil, and coal tar appear to protect timber from the less destructive species of Termites, but repeated applications are necessary if the timber is exposed to the weather or is liable to split. For underground work several coats of boiling coal tar add to the life of timber, but this treatment alone cannot be said to be of much value against even the less destructive species. Several samples of so-called wood-preserving oil and creo-tar oil were tested by the writer in *Mastotermes* infested country, and found to be either useless or in certain cases actually attractive to these insects.

Of the many proprietary preparations tested two only proved to be effective. Hardwood blocks (*E. terminalis*), freed of sapwood and treated with the above, were exposed in heavily infested soils and resisted *Mastotermes* for five years, the period during which they were kept under observation. Equally satisfactory results were obtained with a preparation of arsenate of soda and coal tar compounded by boiling 1½ lbs. of white arsenic and 2 lbs. of commercial washing soda in 1 gallon of water and stirring into it while nearly boiling 1½ gallons of hot coal tar. This mixture proved effective, also in protecting stockyard rails mortised or bolted to termite-infested posts. Further experimentation is required to determine the most suitable quantities of the several ingredients and the best method of preparation, since the blending of the two fluids is sometimes followed by wasteful frothing over and imperfect emulsification. This is especially the case if the soda and arsenic is added to the tar, instead of *vice versâ*.

One of the greatest insect pest problems which the settler in infested country is called upon to face is the protection of stockyards and fences from the ravages of Termites.

Only constant attention and the free use of poison will save even the most substantial fences from serious injury and ultimate destruction, while lighter fences constructed of the less durable timbers may be rendered useless in three or four years, or even less (Plate 7). The sapwood is generally attacked first, and is soon reduced to such a condition that ignition by grass fires is readily effected. A further though minor source of injury is the corrosion of fencing wires which come in contact with the salivary secretions. A small quantity of arsenic, dry or in solution, poured into the top of hollow posts will prevent their destruction by Termites ; but the protection of solid or split posts is more difficult, though it may be effected by pouring a quantity of arsenical solution into a shallow trench opened out around the base of each.

This method appears to be quite satisfactory if the number to be treated is small, but it would probably prove too costly for large undertakings, and it would be attended with grave risk to stock unless carried out with great care.

This aspect of the termite problem is of considerable importance in relation to stock raising and tick eradication, since the rapid destruction of fences by these insects is probably one of the principal reasons for the noticeable scarcity of subdivision and even boundary fences on grazing properties in the Northern Territory.

F. "White-Ant" Proof Buildings.

The majority of buildings throughout northern Australia are constructed of a wood framework resting upon hardwood blocks or piles. Between the top of the piles or blocks and the floor joists galvanized iron plates or stump-caps are interposed to prevent Termites passing from the former into the latter (Plate 8). The length of life of a house block varies greatly according to the nature of the timber employed, the steps taken to protect it, and to the activity of Termites. Ten to fifteen years is probably about the average life of a block under ordinary conditions, but sometimes in less than half this period Termites have made serious inroads into it, if they have not actually hollowed out the core through its entire length (Plate 9). The timber between the heartwood and the sapwood is the most durable, and this part generally remains long after the inner and outer layers have disappeared. As a rule the block is reduced, sooner or later, to a mere shell, and the corrosive action of a fluid secreted by the insects destroys the metal cap, thus permitting direct communication with the superstructure (Plate 10). Provided that piles and stump caps are examined from time to time and renewed when necessary, and that no other means of access are provided, this plan of construction is quite effectual. Instances are known, however, of such buildings having been damaged through Termites entering them by means of a sapling thoughtlessly placed against a wall to support a climbing plant, or by other similar means.

Ferro-concrete piles, brickwork, or masonry are sometimes substituted for hardwood piles, and in such cases the buildings are generally considered to be " white-ant proof." In reality these buildings are proof only against the attacks of those species which do not construct covered-ways up the outer surface of the supporting piles, foundations, or concrete sills of stairways, &c. In Australia there are at least five species of Termites which do construct such covered-ways, namely *Mastotermes darwiniensis*, *Rhinotermes reticulatus* (Plate 11), *Microcerotermes nanus*, *M. serratus*, and *M. turneri*. In the case of the first-named species the work of bridging the gap between the earth and the floor joists 5 or 6 feet above is a matter of a few hours. Generally the construction of these covered-ways is carried out at night, but one has frequently seen the work in full progress during the day or even in the full glare of the sunlight. The soldiers and workers of most species shun light of any kind, and rarely expose themselves even during building operations; *Drepanotermes rubriceps* and *Eutermes triodiæ*, however, are notable exceptions, as both species move freely on the surface when gathering grass and other vegetable matter for food.

Another type of so-called " white-ant proof " building is that in which the superstructure rests upon a solid and continuous floor of concrete, to which the frame is fastened by bolts imbedded in the foundation. Provided that (1) care is taken to prevent the construction of covered-ways over the concrete bed, that (2) the concrete is of good quality and that (3), none of the studs or verandah posts pass through the concrete to the soil below, this plan is certainly to be recommended. Very often, however, neglect of any one of these precautions exposes the building to serious risk of damage.

The perseverance of *Mastotermes* in their endeavours to reach vulnerable parts of a building, under protection of covered-ways was exemplified in the case of one of the Government offices in Darwin, where these pests raised nightly for a couple of weeks a mass of earthy material which covered one end of a concrete sill and extended to the woodwork of a flight of steps resting thereon. Each morning about a shovelful of mortar-like material was removed from the sill and the earth saturated with kerosene or boiling water. Beyond destroying a few hundred workers and soldiers at each application there was no apparent diminution in the efforts of the Termites to destroy the staircase until the soil surrounding the exit holes was moistened with a solution of corrosive sublimate. In several other similar cases saturation of the soil with arsenate of soda (10 per cent. solution) proved quite as effective as treatment with corrosive sublimate.

As mentioned elsewhere in this paper, concrete or cement of poor quality offers very little resistance to *Mastotermes*, although inferior material appears to deter other species unless cracks develop and thus open the way to some of the smaller species. The destruction of a number of books in a book-case in the Veterinary Laboratory at Fannie Bay, near Darwin, was due to the attacks of *Microcerotermes nanus*, which gained access to the interior of the building by means of a crack in the concrete foundation and floor.

It is hardly necessary to remark that, if studs and verandah posts pass through the concrete into the soil below, such foundations not only offer no protection from Termites but greatly increase the difficulties of locating and controlling any invasion by them. *Mastotermes darwiniensis*, *Rhinotermes reticulatus*, *Microcerotermes nanus*, and *Eutermes sp.* (?) appear to be the most important species in this connexion. Extensive damage to the quarantine building on Channel Island, a small rocky island in Port Darwin, was due to structural defects of this kind or to the use of the inferior material in the foundations, or to both causes.

Double walls, whether of stone or brick, are a source of danger unless precautions are taken to prevent Termites from reaching door or window frames, wooden ventilators, and rafters. Instances of such injury, in part, were to be seen in the Court House at Darwin.

G. Miscellaneous Examples of Destruction caused by Mastotermes.

Two American oak water kegs were placed on cases of tinned meat under the shelter of an earth-floored verandah. A few months later the earth was noticed to be damp, and on raising the kegs some of the staves were found to have been pierced by Termites. Further examination showed that the wooden cases were practically destroyed, though externally apparently quite intact, paper labels on the tins gone, and the interstices between the tins filled with earthy matter.

A party travelling overland found that a leather pack-bag containing sugar and other foodstuffs which had rested on the ground had been penetrated by Termites overnight, and a quantity of sugar removed.

A picture-frame hanging on a cypress pine wall and a gun-stock resting on a floor of similar wood were attacked by Termites. In both cases the boards, and in the latter the ebonite heel-plate also, were pierced, and there was no external evidence of Termites being in the buildings until the articles were removed. There are many instances of furniture having been damaged in this manner.

An experimental plot of cassava appeared to be thriving until the plants were blown over during a storm. Upon examination it was found that the stems and tubers were hollow and infested with *Mastotermes* (Plate 2).

A considerable quantity of grass hay (indigenous grasses) was destroyed in an earth-floored " termite-proof " shed. Not only was the hay damaged, but its contact with the studs enabled the Termites to gain access to the hardwood frame of the shed, which was also damaged.

Powellised railway sleepers imported for use on the Pine Creek to Katherine railway extension were attacked by *Mastotermes* while lying in the Darwin yards. The sleepers were exposed to a very severe test, and as the insects abandoned their efforts after penetrating in a few places to the maximum depth of ¼ inch, it would appear that the preference given to wooden sleepers treated by this process was fully justified.

A leaden water pipe is stated on good authority to have been pierced by *Mastotermes* in search of water.

Kerosene cases saturated with oil from leaky tins are frequently destroyed by *Mastotermes.* Pine boards boiled in creo-tar oil and crude creosote have been similarly attacked when interposed between two pieces of infected timber.

Cow or horse manure dug into garden soil will almost invariably attract *Mastotermes* and other species of Termites.

In addition to the substances previously mentioned as having been attacked by *Mastotermes,* the following may be enumerated :—Bone, ivory, horn, leather, greenhide, dried hides, jute, cotton and woollen fabrics, sisal hemp (Plate 12), and linoleum.

7. POSSIBILITY OF ESTABLISHING MASTOTERMES IN THE SOUTHERN STATES OF AUSTRALIA.

A portion of a consignment of casks shipped from Darwin was stated to have contained living *Mastotermes* when delivered to the consignee in Melbourne. Such an occurrence gives rise to speculation as to whether such individuals could under favorable conditions become acclimatised and give rise to a productive community. In all probability the casks were infested with soldiers and adult, or nearly adult workers only, which castes, at present, are not known to ever become productive. If, however, the transported individuals comprised very young larvæ, there is a distinct possibility that some of them might be converted into neoteinic royalties, capable of producing forms of the ordinary castes. Doubtless climatic conditions would be an important factor in determining the fate of a community transplanted from the north to the south, but it would be unwise to assume that successful transplantation is impossible on these grounds alone.

8. CONCLUSION.

The total eradication, or even reduction to a negligible quantity, of the termite population of a given area, whether it be a small town, farm, or station, appears to be quite impracticable if not impossible of attainment; but the prevention of most of the loss caused by these insects is distinctly possible if known methods of control were in more general use. A knowledge of these methods could be usefully extended by practical demonstrations and expert advice; but until more research work is undertaken preventative and control measures must be, of necessity, very limited in their application.

The following are suggested as lines along which investigational work might be profitably undertaken :—

1. The collection of material for the completion of a census of Australian Termites.
2. The study of the life history and habits of these species, and especially of *Mastotermes darwiniensis*, *Coptotermes* spp., *Eutermes* spp., *Microcerotermes* spp., *Mirotermes* spp., and other wood-eating forms.
3. The study of soil and other conditions, with a view to determining the reason for the absence of destructive species in certain localities adjacent to infested areas.
4. To devise means whereby timber, and especially that used in fences, stockyards, station and farm buildings, telegraph poles, mine- and well-shafts, house blocks, and similar purposes, could be cheaply and effectively treated to render it resistant for long periods to termite attack.
5. To investigate the termite resistant properties of imported and indigenous timbers suitable for the above purposes.
6. To devise simple and reliable formulæ for compounding preparations for the protection of timber.
7. Experimentation with arsenic, sodium cyanide, and other chemicals as means of rendering soil poisonous or repellant to Termites and to determine their effects upon plant growth.
8. To ascertain the most effective intestinal poison for Termites, and the best method of distributing it in a palatable form.
9. To determine the insecticidal value of chemical fertilizers in cultivated soil, their value in promoting more vigorous and rapid growth, and the increased resistance, if any, to termite infestation, and the enhanced value, if any, of such crops due to their use.
10. To roughly estimate the annual loss due to Termites.

EXPLANATION OF PLATES.

1. Excavation to show nest of *Mastotermes darwiniensis* Frogg. in Ceara rubber tree.
2. Cassava plant, showing stem and some of the tubers hollowed out by *Mastotermes.*
3. Coconut palm destroyed by *Mastotermes.*
4. Eucalyptus grandifolia trunk ring-barked by *Mastotermes.*
5. E. grandifolia before death of tree and shedding of bark. Tree on left of figure is more extensively ring-barked and the leaves are beginning to fall.
6. Poinciana tree ring-barked by *Mastotermes.*
7. Fence post destroyed by *Mirotermes* sp. The wires are badly corroded where they pass through post or nest.
8. Weatherboard dwelling, built on wooden piles. Stump caps or metal plates interposed between top of piles and superstructure to prevent passage upwards of Termites.
9. House piles from the above, after about ten years' service, showing condition under metal plates.
10. Metal plate from one of the above piles, showing corrosive action of termite secretions and hole through middle through which access was gained to floor joists.
11. A so-called "White Ant" proof house, showing covered-ways constructed by *Rhinotermes reticulatus* up the outside of a concrete pile and around the metal plate.
12. Bale of sisal hemp fibre attacked by *Mastotermes.*
13. Mango tree destroyed by *Mastotermes.*
14. Hardwood fence—post and rail—destroyed by *Mastotermes.*
15. Softwood case destroyed by *Mastotermes.*

PLATE 1.

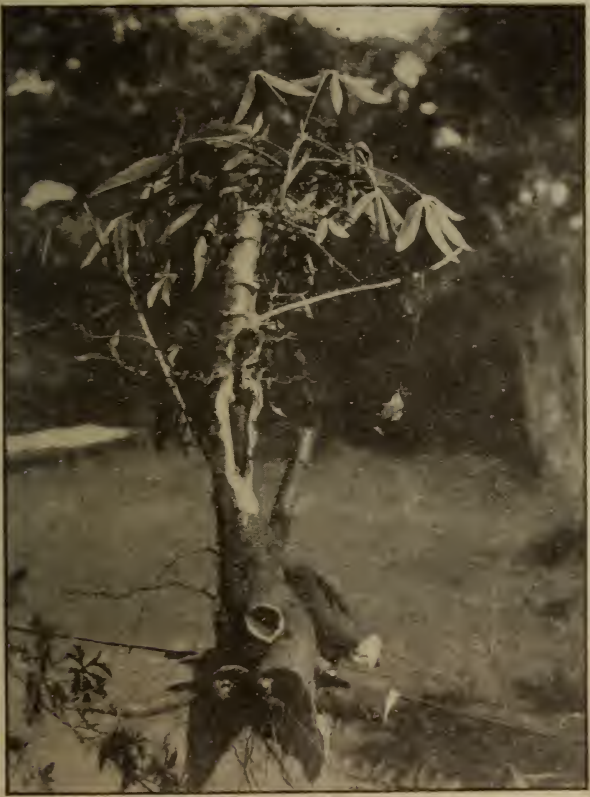
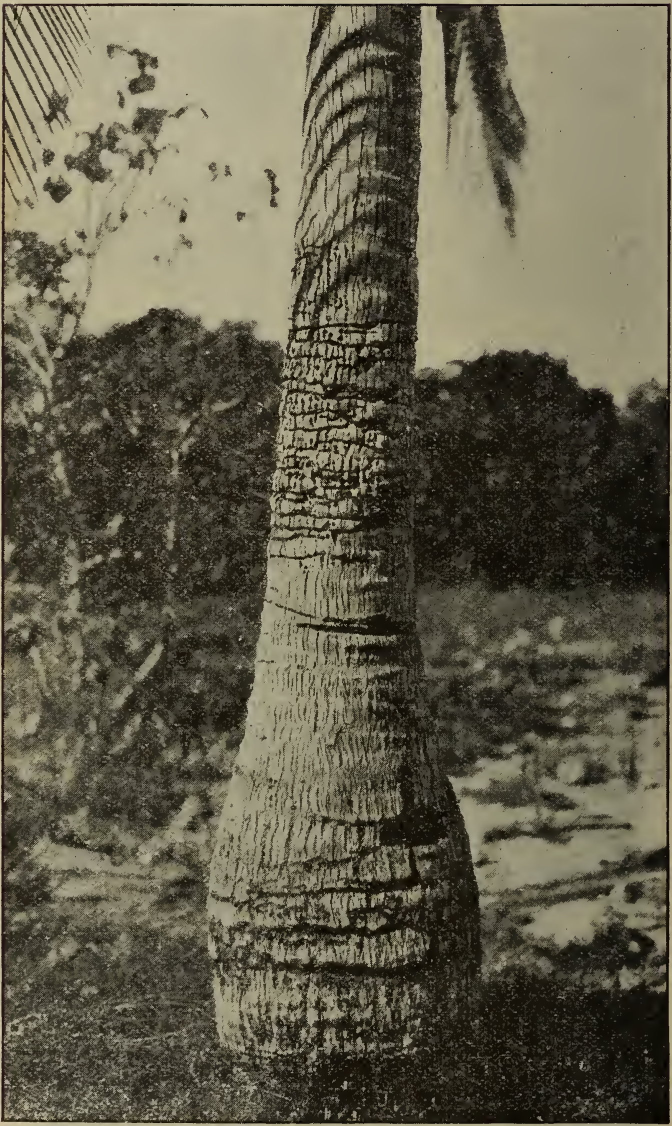


PLATE 2.



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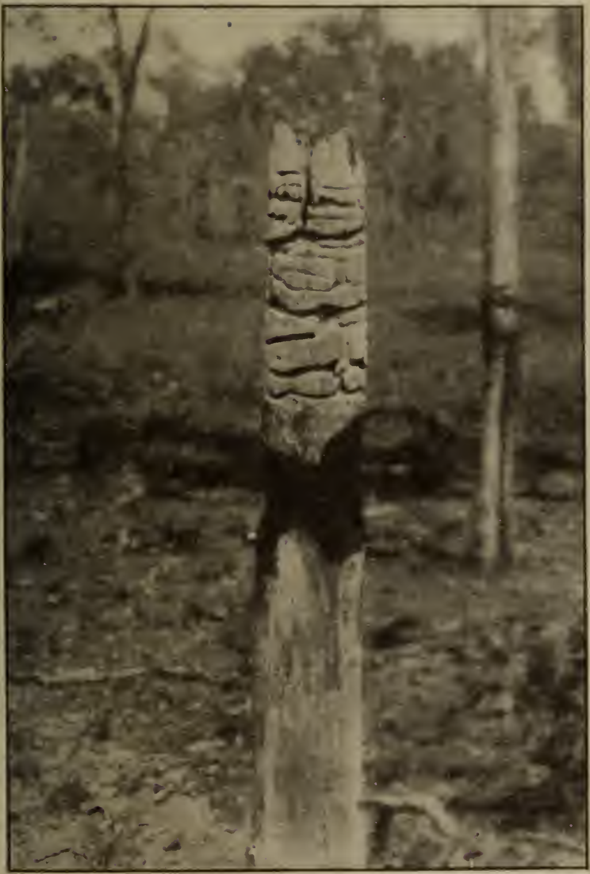

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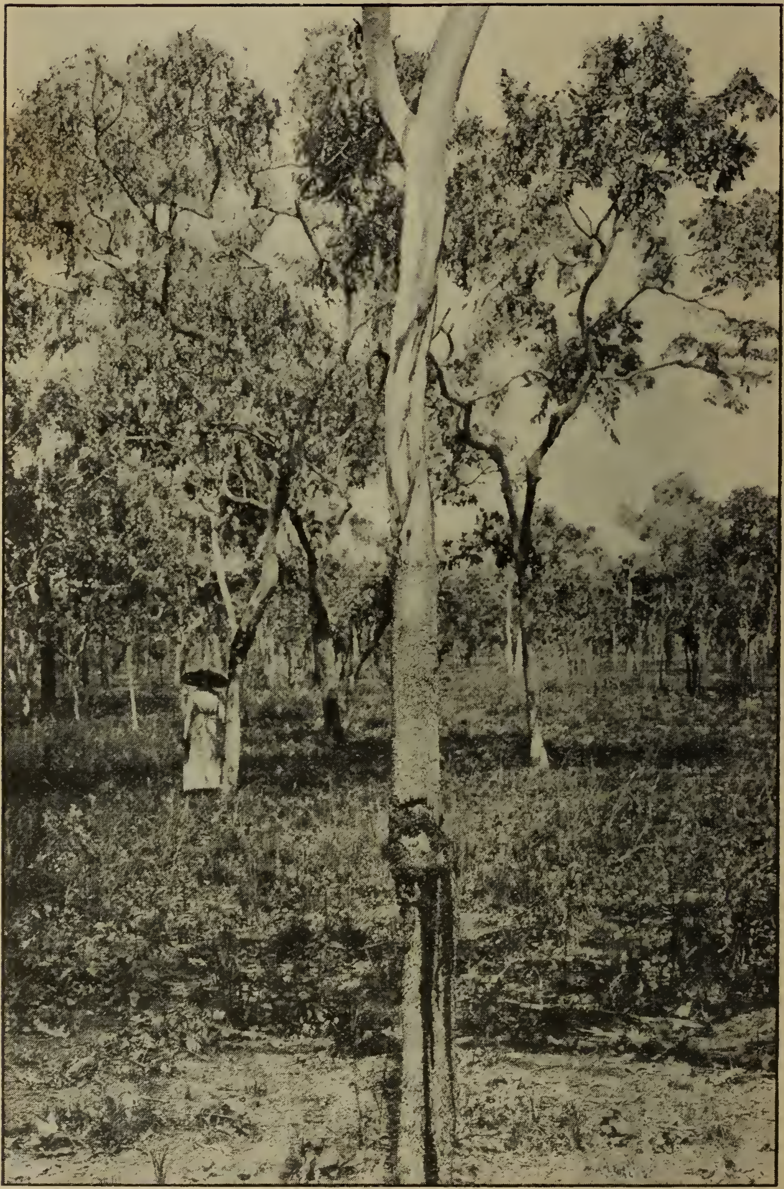

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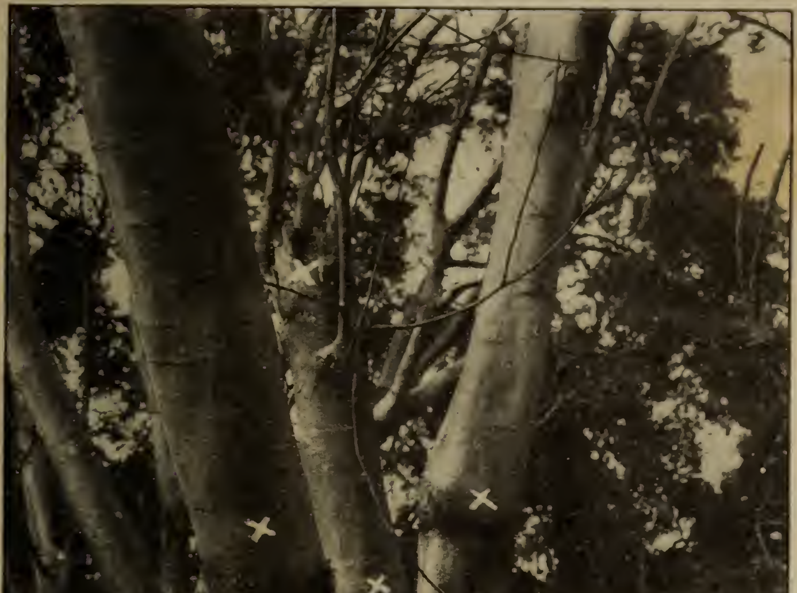

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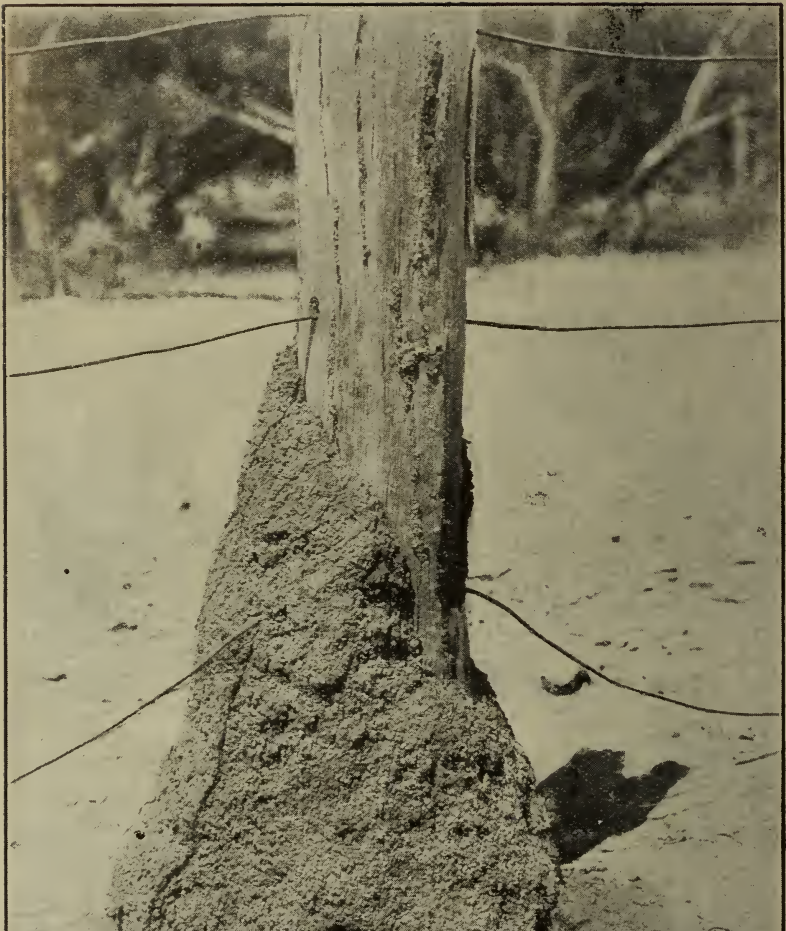

PLATE 7.

PLATE 8.

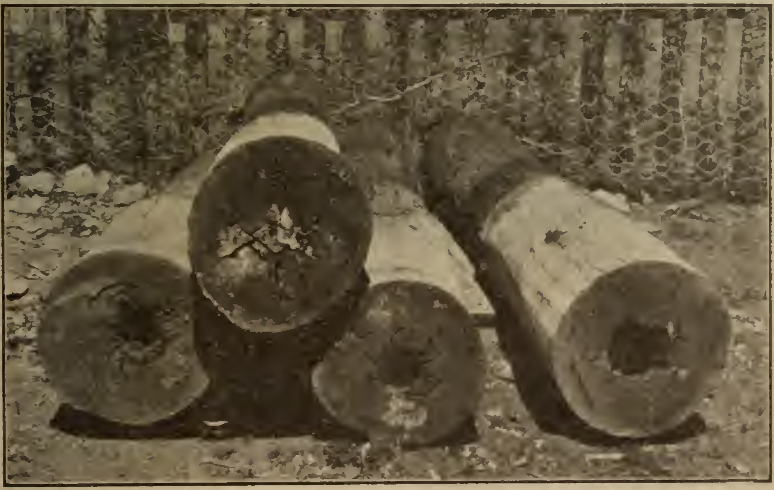

PLATE 9.

PLATE 10.

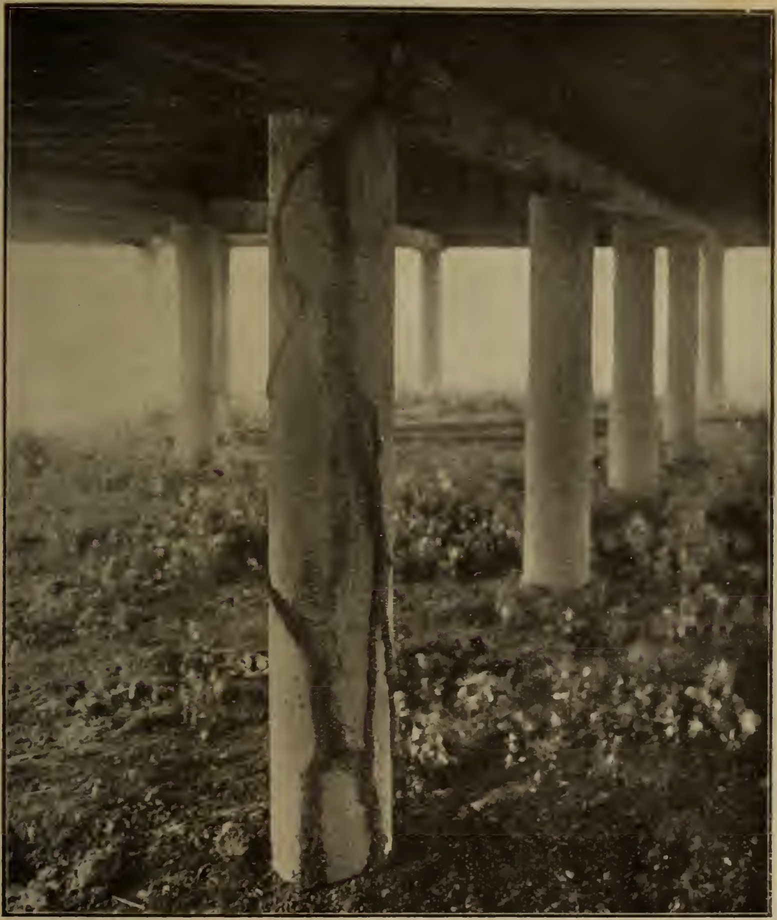

PLATE 11.

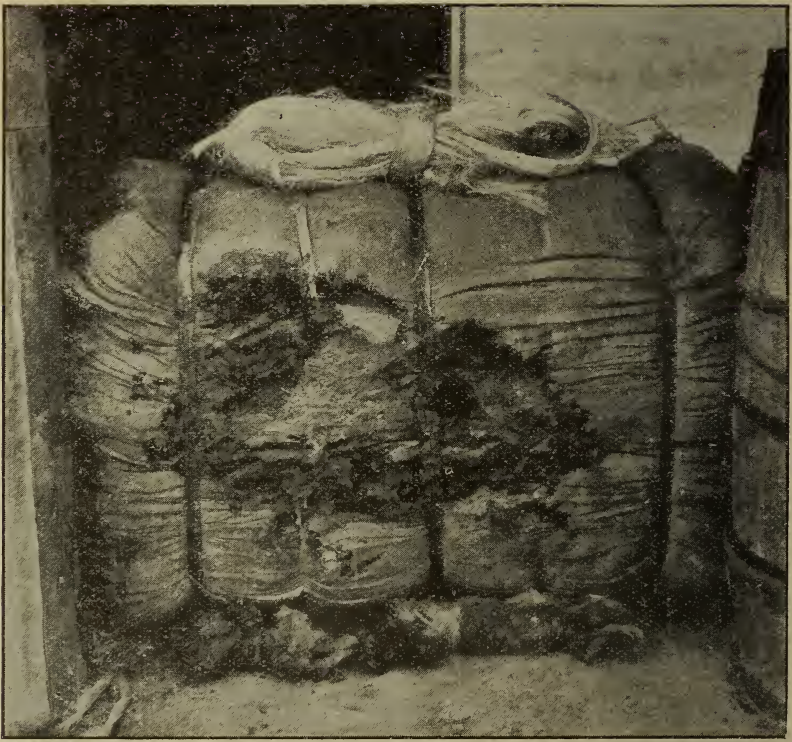

PLATE 12.

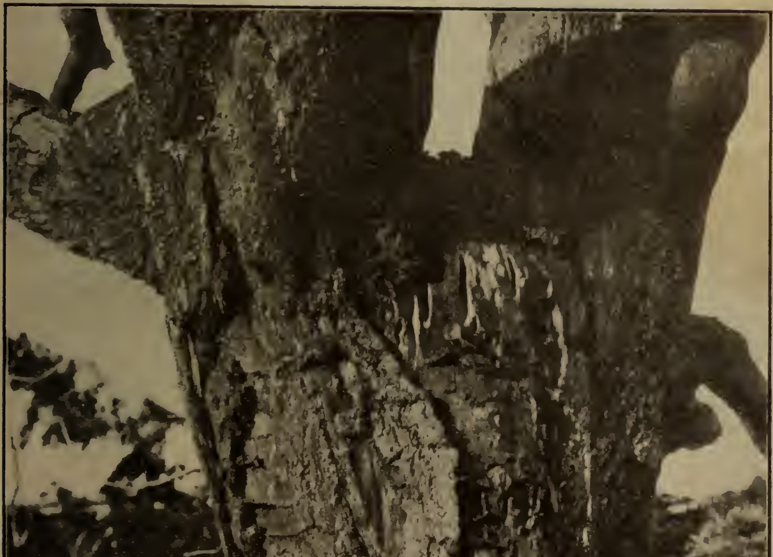

PLATE 13.

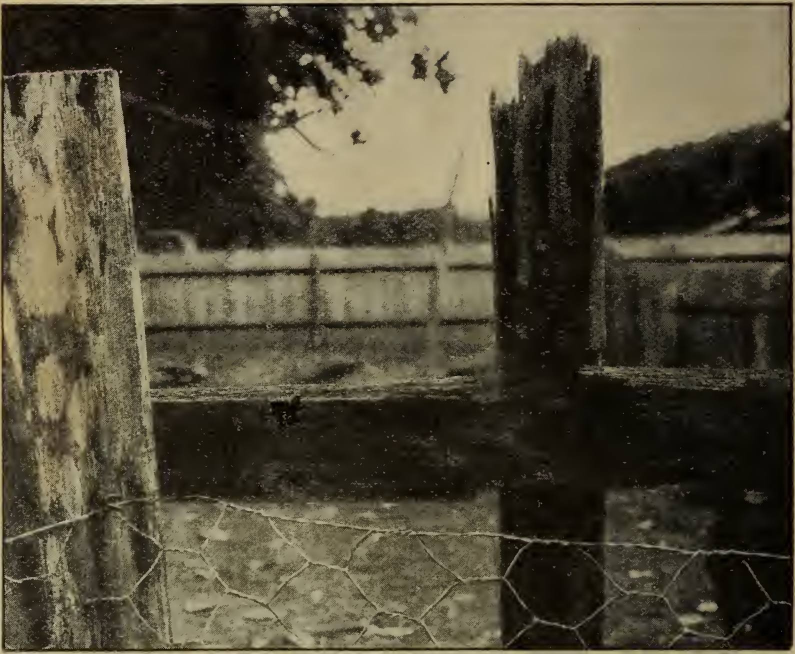

Plate 14.

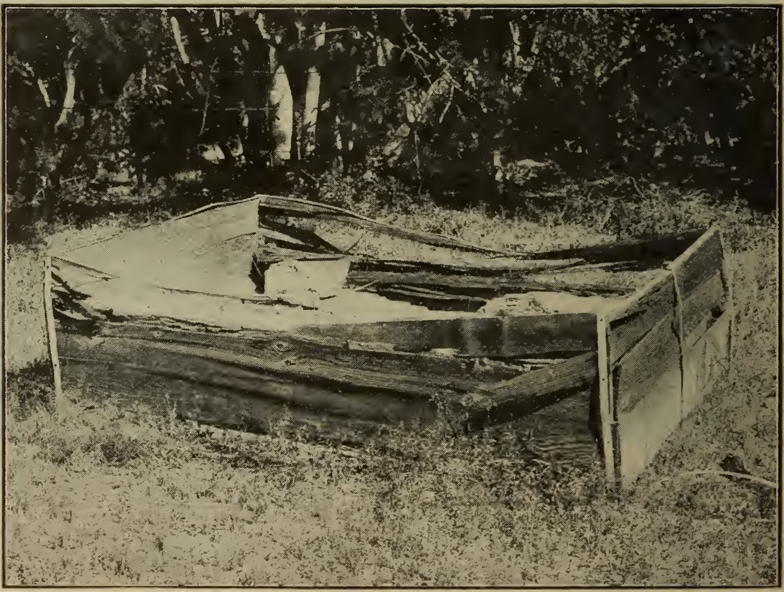

Plate 15.

By Authority:
Albert J. Mullett, Government Printer, Melbourne.

nted from The Medical Journal of Australia, January 14,1922.

THE "MESTOZOS" OF KISAR, DUTCH EAST INDIES.

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Scattered through the relatively scanty modern literature relating to European Colonization of tropical countries are found various references to a Dutch community which has resided for several generations at Kisar, a small island situated some 30 miles northward from Timor, between the parallels of latitude 8° and 9° south of the equator. Professor MacMillan Brown ("The Dutch East", page 204) has woven around this community a romantic tale of settlement in 1655 of wise government by a Dutch sergeant and of retention of the Protestant religion through many vicissitudes extending over 250 years. On the other hand a leading antagonist of the settlement of tropical Australia by a white race has publicly denied (at the Australasian Medical Congress of 1920) the very existence of this community and even of the island itself. The matter is one of much practical interest, as it is in reality an actual, if unpre-meditated experiment on a fairly extensive scale in white settlement in the tropics Advantage was therefore taken during a recent official visit to the Dutch Indies of facilities afforded by the Dutch authorities for access to official records relating to these people (who are officially termed "Mestizos") over a period of more than 100 years. My inquiries in the Small Sunda Islands yielded an opportunity of landing at the island itself and of meeting a large number of the Mestizo-residents. Others were also met at Keopang (Dutch Timor).

HISTORICAL.

Genealogical trees, which have been compiled by the Dutch administration from the results of exhaustive local inquiry,show that at various dates between 1783 and 1819 there came to Kisar as soldiers or officials nine men of Dutch origin who took to themselves wives. Of these, five married women of Dutch blood like themselves and four married women who were more or less tinged with colored blood. None of the families date back further than the last quarter of the eighteenth century at earliest. In 1819 the Dutch East India Company decided to withdraw from Kisar the little garrison of soldiers and officials which had been posted there for over a hundred years previously. All the European families except these nine and probably three or four others of originally European name who had become almost indistinguishably submerged in the native population thereupon left the island.

The Dutch had built two small forts,one near the landing on the western side and one about a couple of miles inland on a small hill commanding the native village of Wonreli, The little European community left behind after the withdrawal,appear to have taken up

their abode in and about the latter of these forts, the settlement being called Kotta Lama, the Malay equivalent of "Old Town" or "Old Fort". The commandant of the post in 1817 was a certain Johannes Willem Joostensz, who had been born in Macassar in 1767 of Dutch parentage and who went to Kisar first in 1783. He there married a Dutch girl in 1788. He remained after the withdrawal and many of his descendants are now living in Kisar or at Koepang. Amongst the documents made available by the Resident at Koepang was a copy of a personal statement made in 1817 by this man, which gives precise dates of the principal details of this personal history. Portions of his statement furnish quaint sidelights on the customs of the Dutch in the Indies 150 years ago. For example, Joostensz as a child was taught dancing so that he might dance for the amusement of the Governor of Banda, and the governor was so pleased with the results that the soldier who had acted as dancing master was made a non-commissioned officer. Joostensz also refers casually in his official statement to the fact that when his eldest legitimate son was baptized in the old church at Wonreli, one of his natural sons by a heathen woman living in an adjacent island was baptized at the same time

The colored population of Kisar numbered at least several thousands at the time of the withdrawal of the Dutch garrison. At the present day it comprises some 9,000 people. There was, however, very little inter-marrying between the European community and the natives after the withdrawal, a fact which can be checked fairly accurately from the genealogical trees. The Dutch East India Company discouraged marriages by its employees with native women and encouraged them to marry Christian wives of European or mixed origin. This tradition appears to have persisted throughout their history, even at their most submerged stage.

For some sixty years after 1819 the little community was practically forgotten and unvisited. Until the island is seen this is rather difficult to understand and a suggestion has been made to explain the continuance of European physical characteristics by the visits of whaling vessels. From a seaman's point of view, however, Kisar is a wholly unattractive place for a deep-sea sailing vessel. It is almost square in outline, possesses no harbours nor good anchorages (over 200 fathoms of water is found a short distance outside its dangerous reefs) and has no attractions in the way of wood or water readily accessible to ships' boats. From the sea it looks a dry unattractive place. The old Portuguese town of Dilly (Timor) is readily reachable in either monsoon and possesses an excellent harbour. Several better places than Kisar from the seaman's point of view are within a day's sail. The disturbed condition and interference with the local administration which formed an aftermath of the Napoleonic wars and the British occupation of Java together with extensive military operations over a period of many years by the Dutch against native kingdoms in Java and other islands, seem to have caused the Kisar people to have been totally overlooked, even to the extent of their omission from the records of civil status.

During the 'eighties of last century Baron Van Hoevell, then Resident at Ambon (Amboina) in which district Kisar was then located for administrative purpose, became aware of this community and thereafter took much interest in them. They had degenerated very much both

physically and mentally had relapsed into heathenism and had also lost the Dutch language. They had passed under the rule of the native Rajah of Wonreli, and except for the tenacity with which they kept their marriages within their own community and retained their family names, had practically lost all marks of European civilization. Several families are said however, to have preserved their family Bibles up to 1908 when they were unfortunately destroyed in a typhoon which swept the island.

Baron Van Hoevell's efforts resulted in assistance from the Dutch Goverment for the rescue of these descendants of forgotten Dutchmen from their lowly state. Christianity was re-introduced, marriages were celebrated in accordance with the regulations for native Christians and openings were provided for those who wished to proceed to other parts of the Indies. A Wijkmeester or head man was appointed. This official, Mr. C. Caffin still holds the position and at the age of over 70 is a tall and striking-looking man who would pass anywhere for a bronzed European. Attempts were made to employ Mestozos in the navy and in the police, but without much success. Eventually twelve houses were built at Koepang (Dutch Timor) for the use of any of the Kisar people who desired to proceed there. Free education for their children was provided at the European School at Koepang and they were encouraged to work at various industries.

The community now numbers some 200 at Kisar, with about another hundred at Keopang and in various parts of the Indies. One of the Caffin family is a leading merchant at Gorontalo, in North Celebes, another is an officer of the Civil Service in charge of one of the neighbouring islands and a third is a managing clerk for a commercial firm in Dilly. A fourth is Wijkmeester of Kisar. Trades carried on by the Mestizos at Kisar and Koepang comprise weaving of a fairly good quality of cloth for sarongs and other native garments, chairmaking, carpentry and tailoring. They also breed goats, cultivate maize, vegetables and fruit and catch fish. Their houses at Kotta Lama are clean and well kept but except for a little European furniture, do not differ materially from those of the natives in the neighbouring village.

PERSONAL INQUIRY.

Some twenty-four of these people of all ages were interviewed at Keopang on May 3 and 10 1921; another eight were seen on the steamer between Koepang and Kisar and on May 5 1921, a visit was paid to Kisar itself. I was then able to visit their town of Kotta Lama and the native village of Wonreli and to see the majority of the Mestizo residents.

There can be no reasonable doubt as to the European origin of these people. Fully a third of those seen were of obviously north European descent with fair hair, blue eyes, fair complexion and skin and distinctly European features and build. European coloring and complexion were not uniform in any one family seen, but even in those families and individuals who show considerable intermixture with natives blood, the European features persists. A number of really good-looking people were seen, any of whom could have passed for a European of unmixed blood. It was a curious experience to see at the landing place these flaxen-haired, fair-skinned, blue-eyed folk, speaking only Malay amongst themselves, gathered in little groups apart from the crowds of natives against the background of the old fort walls.

The head teacher of the European School at Keopang spoke highly of the mental attainments of the Kisarese children under his charge.

There is no mediocrity amongst them; they react to education either very well or very poorly. Copybooks and school records produced showed a high average amongst the majority.

The report of a medical examination conducted in 1904 at Kisar described the Mestizo children of that day as mentally backward and physically degenerated. Inspection during my visit showed no obvious evidence of physical degeneration. Malaria exists in Kisar and of some twenty children examined, six had splenic enlargement of moderate extent. It is probable that the active and practical interest taken by the government in their welfare of late years has improved their food supply, both in scope and quantity, with consequent improvement in the physique and mentality of the present generation.

The adults were for the greater part healthy, robust-looking people Some of them were pock-marked. A severe outbreak of smallpox is recorded as having occurred about 1901. The fertility of the women is very marked and there appears to be no tendency for the race to die out. Up to recent years the girls have married at an early age and motherhood at fourteen is not unusual.

In response to a request for suggestions in connexion with the welfare of these people, I pointed out to the Chief Medical Inspector of the Civil Medical Service the desirability of undertaking a series of Binet-Simon or Porteus tests for mental reaction amongst Kisarese children at the Koepang European School and also at Kisar and of making an examination for hookworm, in view of the known influence of this disease on mental reaction and general development.

CONCLUSIONS.

The following conclusions may be drawn :-

1. That nine families of originally north European or mixed north European and native blood have persisted on Kisar for over one hundred years and have bred to five and six generations. In the case of the Joostensz family, the known date of birth of the eldest Kisar-born child of European blood was 1789. His descendants down to the year 1914 numbered thirtyeight at least and possible more. His father J. W. Joostensz, Commandant at Kisar in 1817, was born at Macassar in 1767, giving an uninterrupted period of tropical residence for his family of 154 years on the paternal side and at least 135 years on the maternal side.
2. That this has not been accompanied by loss of European characteristics of complexion and features, except as a result of admixture of native blood, and that even when so diluted the European physical characteristics still come out strongly in the fifth and sixth generations.
3. That the European standard of mentality, as shown by reaction to European methods of education, persists in substantial degree after five and six generations.
4. That these characteristics have survived in spite of environmental conditions and association lasting for over sixty years, from 1819 onwards, and probably for some seventy years or more which are generally supposed to be totally unsuitable for persons of European stock, These conditions have included native standards of food and food supply endemic malaria, and psychological effect of what must have been for the earlier generations an acute sense of abandonment by their own race, life under the rule of native chiefs, constant association with a native race of low mentality, loss of European language and European religion,

inter-breeding to a high degree and constant exposure to a tropical climate.

5. That there is nothing in the available history of these people to show that a tropical climate per se has tended to produce degenerative effects on them or to limit fertility.

6. That whatever evidence they may have shown of lowered physical or mental activity in the past can be fully explained by the environmental conditions of food supply, malaria and particularly of native associations, aided possibly by the accentuation of stock-weaknesses arising from inter-breeding over several generations.

7. That the measures adopted by the Government during recent years appear to have resulted in definite improvement in their physical and mental condition, particularly amongst the children of school age

REFERENCES.

The following is a list of references to publications and official documents containing information relating to the Kisarese Mestizos which were consulted in connexion with the foregoing enquiry.

1. Family story from J. W. Joostensz, Commander of the Fort at Kisar 1817.
2. A report on the physical condition of the Mestizos, Dr. Huijsman 1904.
3. Fragment of an article by G. W.W.C.Baron Van Hoevell, 1889
4. Genealogical trees of the Mestozos at Kisar.
5. Report on Kisar by Lieutenant Testeege, Gezaghebber at Kisar from about 1913 to 1916.
6. "Vitense Kolonien" Van Rol.
8. Pamphlet by A. B. Meyer "Die Europaische Colonie auf der Insel Kisir" 1882 See 10.
7. "Reis H. M. Siboga" door Dr. Max Weber
9. The "Dutch East" Professor MacMillan Browne.
10. Encyclopaedie van Nederlandsch Oost Indie II H-M Article "Kisar" with references to 8 and 11.
11. Articles by G. W. W. C. Baron Van Hoevell, For References see 10.

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